MP135E

Q-545 Stage

User Manual

Version: 1.0.0 Date: 10.07.2015

This document describes the following products:

- **Q-545**
  Q-Motion linear positioning stage, piezoelectric inertia drive

  This document applies to various model versions of the Q-545. The model version of the Q-545 is coded in the order number by means of three characters after a period. Meaning of the places and valid values:

  First character after the period:
  Travel range
  1 = 13 mm
  2 = 26 mm

  Second character after the period:
  Sensor equipment
  0 = without sensor
  4 = with sensor

  Third character after the period:
  Vacuum suitability
  0 = suitable to 10^{-6} hPa
  U = suitable to 10^{-9} hPa

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This manual contains information on the intended use of the Q-545.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

The latest versions of the user manuals are available for download (p. 3) on our website.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in minor injuries or damage to the equipment.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning sign affixed to the product that refers to detailed information in this manual.

1.3 Definition

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the stage is mounted horizontally. The contact point of the load is in the center of the platform.
Linear encoder	The linear encoder is an incremental sensor for capturing changes in position. Signals from the sensor are used for axis position feedback. After switching on the controller a reference point definition must be performed before absolute target positions can be commanded and reached.

1.4 Figures

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.5 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

Description	Document
E-870.10, E-870.11, E-870.21, E-870.41 Piezomotor / PiezoMike Drive Electronics, OEM Board, 1 to 4 Channels	E870T0001 Technical Note
E-870.1G, E-870.2G, E-870.4G Piezomotor / PiezoMike Drive Electronics, Bench-Top, 1 to 4 Channels	E870T0002 Technical Note
E-871.1A1 Q-Motion Controller, 1 Channel, USB Interface	PZ241E User Manual
PIMikroMove	SM148E Software Manual

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 59).

INFORMATION

For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD. Availability of the manuals:

- Password-protected manuals: FTP download directory
- Freely available manuals: PI website

➢ Follow the corresponding instructions for downloading.

Downloading freely accessible manuals

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding product category.
4. Go to the corresponding product code.

   The available manuals are displayed.
5. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Downloading password-protected manuals

1. Insert the product CD in the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.
5. Open the FTP download directory (ftp://pi-ftp.ws).
   - Windows operating systems: Open the FTP download directory in Windows Explorer.
6. Log in with the user name and the password from the Release News.
7. In the directory of the corresponding product, go to the Manuals sub-directory.
8. Copy the desired manual to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

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General Safety Instructions 5
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Measures for Handling Vacuum-Compatible Products 6

2.1 Intended Use

The Q-545 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

In accordance with its design and realization, the Q-545 is intended for single-axis positioning, adjusting and shifting of loads at different velocities in interval operation. The Q-545 uses a PIShift piezomotor as a drive. When at rest, the drive is self-locking, requires no current, generates no heat, and maintains its position.

The Q-545 can be mounted in any orientation. The specifications of the Q-545 apply to horizontal mounting (p. 61).

The Q-545 is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment. For further information on the operating conditions of the Q-545, see "Technical Data" (p. 61).

Some models of the Q-545 are equipped with a linear encoder for direct position measurement.

The intended use of the Q-545 is only possible when completely mounted and connected. The Q-545 must be operated with suitable electronics (p. 15). The electronics are not included in the scope of delivery of the Q-545.

2.2 General Safety Instructions

The Q-545 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the Q-545.

- Only use the Q-545 for its intended purpose, and only use it if it is in a good working order.

- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the Q-545.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the Q-545.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the Q-545 on to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the Q-545 after you have read and understood this user manual.

Personnel qualification

The Q-545 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

2.4 Measures for Handling Vacuum-Compatible Products

When handling the vacuum version of the stage, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. In addition, the Q-545.xxU models are wipe cleaned afterwards and then shrink-wrapped twice in vacuum-compatible film.

- Only touch the stage with powder-free gloves.
- If necessary, wipe the stage clean after unpacking.

3 Product Description

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3.1 Model Overview

Classification of the Q-545 models

The model version of the Q-545 is coded in the order number by means of three characters after a period; see also "Detailed model names". Each character codes a feature of the model version:

	First character	Second character	Third character
Feature	Travel range	Sensor (linear encoder)	Vacuum suitability
Feature value	1 = 13 mm 2 = 26 mm	0 = without sensor 4 = with sensor	0 = suitable to 10^{-6} hPa U = suitable to 10^{-9} hPa

If the value "x" is used in this manual for a character after the period, the corresponding description or instruction applies to all feature values of the corresponding feature.

Detailed model names

Order number	Product name
Q-545.100	Q-Motion Linear Stage, 13 mm Travel Range, without Position Sensor for Open-Loop Operation, 8 N Push / Pull Force, Dimensions 45 × 48 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-6} hPa
Q-545.140	Q-Motion Linear Stage, 13 mm Travel Range, Linear Encoder, 1 nm Resolution, 8 N Push / Pull Force, Dimensions 45 × 48 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-6} hPa
Q-545.200	Q-Motion Linear Stage, 26 mm Travel Range, without Position Sensor for Open-Loop Operation, 8 N Push / Pull Force, Dimensions 45 × 63 × 15 mm (W × L× H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-6} hPa
Q-545.240	Q-Motion Linear Stage, 26 mm Travel Range, Linear Encoder, 1 nm Resolution, 8 N Push / Pull Force, Dimensions 45 × 63 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-6} hPa
Q-545.10U	Q-Motion Linear Stage, 13 mm Travel Range, without Position Sensor for Open-Loop Operation, 8 N Push / Pull Force, Dimensions 45 × 48 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-9} hPa
Q-545.14U	Q-Motion Linear Stage, 13 mm Travel Range, Linear Encoder, 1 nm Resolution, 8 N Push / Pull Force, Dimensions 45 × 48 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-9} hPa
Q-545.20U	Q-Motion Linear Stage, 26 mm Travel Range, without Position Sensor for Open-Loop Operation, 8 N Push / Pull Force, Dimensions 45 × 63 × 15 mm (W × L× H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-9} hPa
Q-545.24U	Q-Motion Linear Stage, 26 mm Travel Range, Linear Encoder, 1 nm Resolution, 8 N Push / Pull Force, Dimensions 45 × 63 × 15 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10^{-9} hPa

3.2 Product View

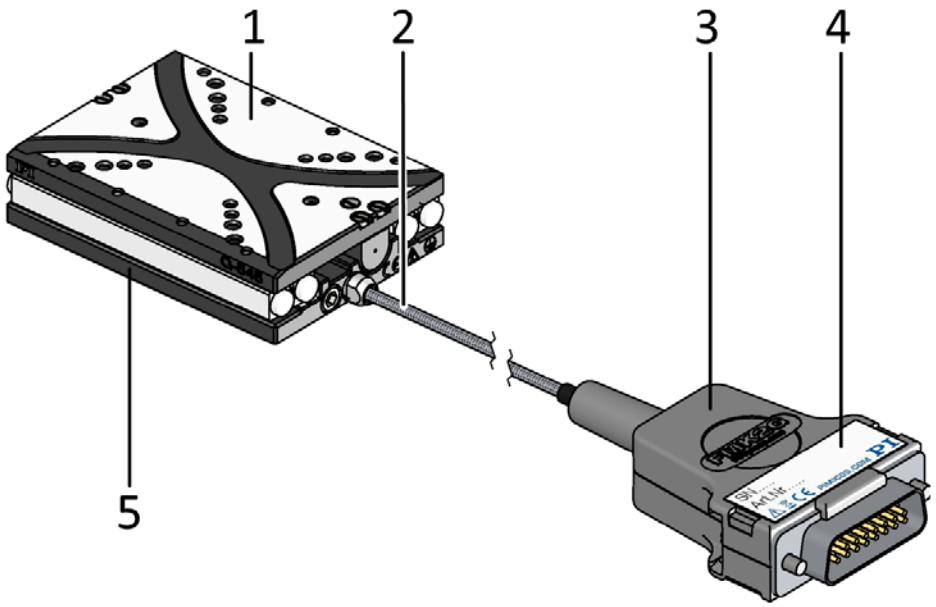

Figure 1: Example for models without sensor: Q-545.200 stage

1 Moving platform

2 Cable exit for drive connection

3 Connection for drive; with Q-545.x00 models: Sub-D 15 (m) connector, with Q-545.x0U models: Sub-D 15 (f) connector

4 Type plate p. 11

5 Base body

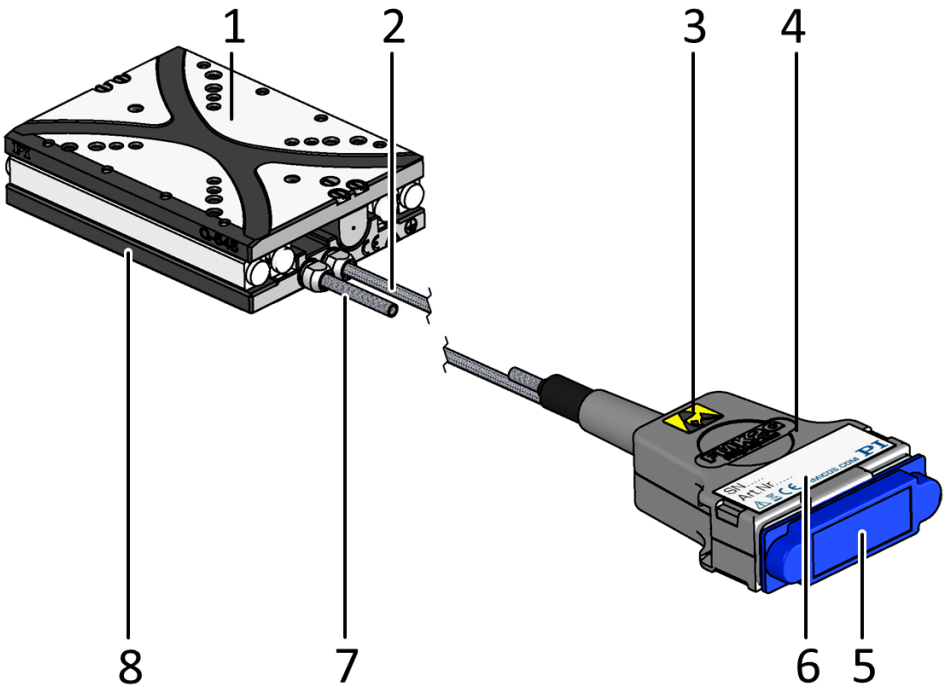

Figure 2: Example for models with sensor: Q-545.240 stage

1 *Moving platform*
2 *Cable exit for drive connection*
3 *Warning sign "Electrostatic sensitive devices"*
4 *Connection for drive and sensor; with Q-545.x40 models: Sub-D 15 (m) connector, with Q-545.x4U models: Sub-D 15 (f) connector*
5 *ESD protection: ESD protective cap with Q-545.x40; nonconductive foil with Q-545.x4U*
6 *Type plate p. 11*
7 *Cable exit for sensor connection*
8 *Base body*

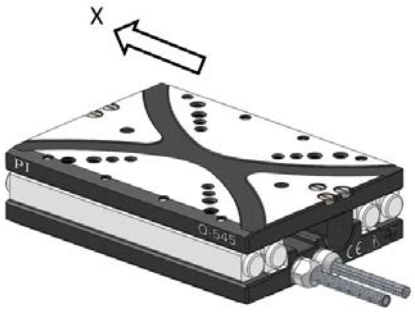

Figure 3: Direction of motion of the platform of the Q-545, Q-545.240 used as example

The arrow in the figure above shows the direction of motion on positive commanding.

3.3 Product Labeling

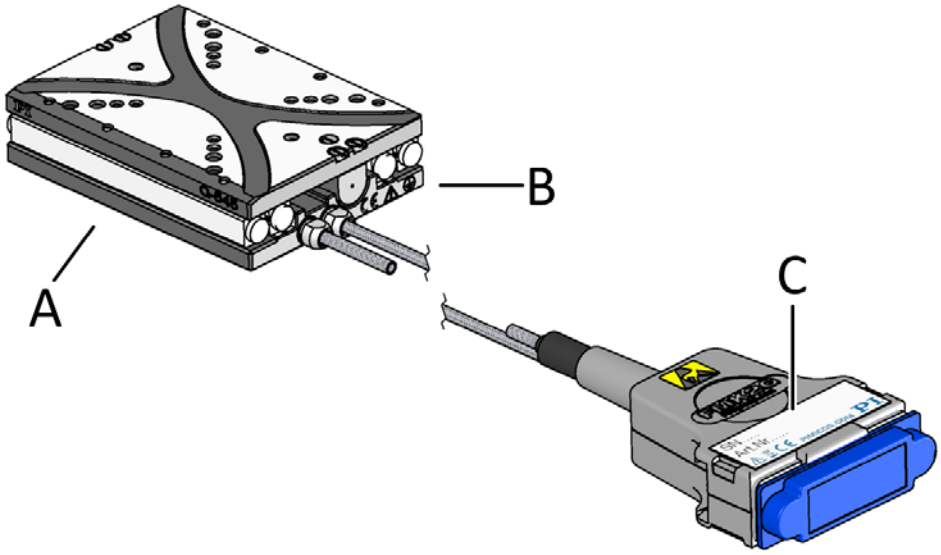

Figure 4: Example for models with sensor: Product labeling and type plate of the Q-545.240 stage

Position	Labeling	Description
A, C	PI	Manufacturer's logo
B, C	CE	CE conformity mark

Position	Labeling	Description
B, C		Warning sign "Observe manual!"
B		Symbol for the protective earth conductor, marks the protective earth connection of the Q-545 (p. 23)
C		Warning sign "Electrostatic sensitive devices"
C	113064246	Serial number (example), individual for each Q-545 Meaning of the places (counting from left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive numbers
C	Q-545.240	Product name (example), the characters following the period refer to the model
C		Old equipment disposal
C	WWW.PIMICOS.COM	Manufacturer's address (website)

3.4 Scope of Delivery

The Q-545 is delivered with the following components:

Item ID	Components
Q-545	Linear positioning stage as specified in the order (p. 7)
5861500010	Screw set for mounting the Q-545, consisting of: ▪ 2 dowel pins A2 2.5 m6 x 5 ISO 8734 ▪ 4 socket head cap screws A2 M2.5x5 ISO 4762
MP139EK	Short instructions for Q-5xx / Q-6xx PIShift stages
Only for models **without** sensor:	
7202500042-0015	Air-side adapter cable for connection to the E-870 drive electronics, Sub-D 15 (f) to Mini-DIN 4 (m), 0.3 m

Item ID	Components
Only for models **with** sensor:	
7202500043-0015	Air-side adapter cable for connection to the E-871 controller, Sub-D 15 (f) to HD Sub-D 15 (m) and HD Sub-D 15 (f), 0.3 m
Only for models suitable for operation to 10^{-9} hPa:	
5604500041	Adapter for operation outside of a vacuum chamber, Sub-D 15 (m/m)

3.5 Accessories

Order number	Description
E-873.UHV1	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 1 m
E-873.UHV2	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 2 m
E-873.UHV3	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 3 m

For Q-545.xx0 models only (suitable for use in a vacuum to 10^{-6} hPa):

Order number	Description
C-815.VF	Vacuum feedthrough (drive and sensor signals), Sub-D 15 (m/f), including C815T0003 Technical Note

Order number	Description
Q-145.1001	Adapter bracket for vertical mounting of Q-545.1x0 stages. Material: Aluminum (3.3206), anodized; mass: 42 g; includes: ▪ 2 dowel pins A2 2.5 m6 x 4 ISO 2338 ▪ 4 socket head cap screws A2 M2.5x8 ISO 4762
Q-145.200	Adapter bracket for vertical mounting of Q-545.2x0 stages. Material: Aluminum (3.3206), anodized; mass: 49 g; includes: ▪ 2 dowel pins A2 2.5 m6 x 4 ISO 2338 ▪ 4 socket head cap screws A2 M2.5x8 ISO 4762

For Q-545.xxU models only (suitable for use in a vacuum to 10^{-9} hPa):

Order number	Description
C-815.VFU1	Vacuum feedthrough (drive and sensor signals), Sub-D 15 (m/m), DN40CF
C-815.VFU3	Vacuum feedthrough (drive and sensor signals), 3 x Sub-D 15 (m/m), DN63CF
C-815.VFU6	Vacuum feedthrough (drive and sensor signals), 6 x Sub-D 15 (m/m), DN100CF
C-815.VFU15	Vacuum feedthrough (drive and sensor signals), 15 x Sub-D 15 (m/m), DN160CF
Q-145.10U1	Adapter bracket for vertical mounting of Q-545.1xU stages. Material: Aluminum (3.3206), uncoated; mass: 42 g; includes: ▪ 2 dowel pins A2 2.5 m6 x 4 ISO 2338 ▪ 4 socket head cap screws A2 M2.5x8 ISO 4762

Order number	Description
Q-145.20U	Adapter bracket for vertical mounting of Q-545.2xU stages. Material: Aluminum (3.3206), uncoated; mass: 49 g; includes: ▪ 2 dowel pins A2 2.5 m6 x 4 ISO 2338 ▪ 4 socket head cap screws A2 M2.5x8 ISO 4762

➢ To order, contact our customer service department (p. 59).

3.6 Suitable Electronics

Electronics		Suitable for	
Order Number	Description	Stage without sensor Q-545.x00 Q-545.x0U	Stage with sensor Q-545.x40 Q-545.x4U
E-870.10	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, OEM Board	☑	
E-870.11	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, OEM Board with Connector Strip	☑	
E-870.1G	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, Bench-Top Device	☑	
E-870.21	PIShift Piezomotor / PiezoMike Drive Electronics, 2 Channels, OEM Board with Connector Strip	☑	
E-870.2G	PIShift Piezomotor / PiezoMike Drive Electronics, 2 Channels, Bench-Top Device	☑	

Electronics		Suitable for	
Order Number	**Description**	**Stage without sensor Q-545.x00 Q-545.x0U**	**Stage with sensor Q-545.x40 Q-545.x4U**
E-870.41	PIShift Piezomotor / PiezoMike Drive Electronics , 4 Channels, OEM Board with Connector Strip	☑	
E-870.4G	PIShift Piezomotor / PiezoMike Drive Electronics, 2 Channels, Bench-Top Device	☑	
E-871.1A1	Q-Motion Controller, 1 Channel, USB Interface		☑

➢ To order, contact our customer service department (p. 59).

3.7 Technical Features

3.7.1 Linear Encoder (Sensor)

Some of the Q-545 models are equipped with an optical linear encoder. For the encoder resolution, refer to the table in the "Specifications" section (p. 61).

Optical linear encoders measure the actual position directly (direct metrology). Therefore, errors occurring in the drivetrain, such as nonlinearity, backlash or elastic deformation, cannot influence the measurement of the position.

3.7.2 Reference Point Switch

The Q-545 models equipped with a sensor have an optical reference point switch.

The commands that use the reference signal are described in the user manual of the controller and/or in the corresponding software manuals.

3.7.3 ID Chip

Q-545 models with sensor contain an ID chip in the connector.

The following data is stored as parameters on the ID chip:

- Information on the stage: Type, serial number, date of manufacture, version of the hardware
- Settings for the sensor: Interpolation rate, corrections of hysteresis as well as of phase and offset, gain values

When switched on or rebooted, controllers from PI read the data from the ID chip.

For more information on the ID chip recognition, see the manual of the controller used.

4 Unpacking

NOTICE

Electrostatic hazard

Touching the pins in the Sub-D 15 connection of models equipped with sensor can damage electrostatic (also: ESD-) sensitive components of the Q-545. For this reason, these models are supplied with ESD protection:

- Q-545.x40: ESD protection cap on the connector (m)
- Q-545.x4U: Electrically nonconductive foil on the connector (f)

➢ Remove the ESD protection from the connection only when you connect the Q-545 to the controller.

INFORMATION

When handling the vacuum version of the stage, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. In addition, the stage is wipe cleaned afterwards and then shrink-wrapped twice in vacuum-compatible film.

➢ Only touch the stage with powder-free gloves.

➢ If necessary, wipe the stage clean after unpacking.

1. Unpack the Q-545 with care.
2. If present, do **not** remove the ESD protection from the connection of the Q-545.
3. Compare the contents with the items listed in the contract and the packing list.
4. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
5. Keep all packaging materials and the ESD protection in case the product needs to be returned.

5 Installation

In this Chapter

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Setting Up a Multi-Axis System 26
Affixing the Load to the Q-545 35
Connecting the Q-545 to the Electronics 38

5.1 General Notes on Installation

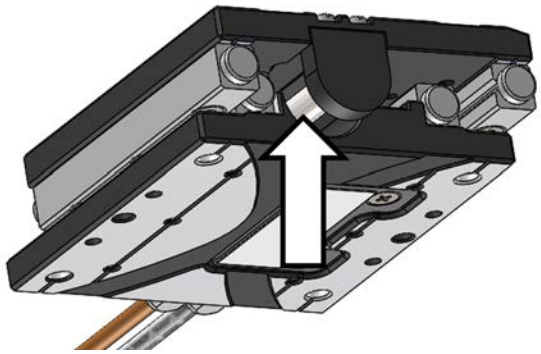


Figure 5: Accessible when the moving platform is driven out: Ceramic rod of the PIShift drive, example Q-545.140

NOTICE

Malfunction due to soiling!

Any type of soiling; e.g., dust, oil, lubricant or condensation, will render the Q-545 inoperable.

- ➢ Keep the Q-545 free from dirt and condensation.
- ➢ Avoid touching the ceramic rod of the drive.

NOTICE

Electrostatic hazard

Touching the pins in the Sub-D 15 connection of models equipped with sensor can damage electrostatic (also: ESD-) sensitive components of the Q-545. For this reason, these models are supplied with ESD protection:

- Q-545.x40: ESD protection cap on the connector (m)
- Q-545.x4U: Electrically nonconductive foil on the connector (f)

➢ Remove the ESD protection from the connection only when you connect the Q-545 to the controller.

NOTICE

Heating up of the Q-545 during operation!

The heat produced during operation of the Q-545 can affect your application.

➢ Install the Q-545 so that the application is not impaired by the dissipated heat.

➢ Ensure sufficient ventilation at the place of installation.

➢ Make sure that the complete bottom side of the Q-545 is in contact with the surface on which the Q-545 is mounted.

NOTICE

Unintentional changes in position with vertical mounting!

If the load exceeds the self-locking of the drive when the stage is mounted vertically, unintentional changes in the position of the moving platform occur. Unintentional changes in position of the moving platform can damage the drive, the load or the environment.

➢ When the stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.

NOTICE

Damage from unsuitable cables!

Unsuitable cables can damage the electronics.

➢ Only use cables provided by PI for connecting the Q-545 to the electronics.

INFORMATION

For optimum repeatablity, all components must be firmly affixed to each other.

INFORMATION

When handling the vacuum version of the stage, appropriate cleanliness must be ensured.

- ➢ Only touch the stage with powder-free gloves.
- ➢ If necessary, wipe the stage clean.

INFORMATION

The positive direction of motion of the axis is given in the product view (p. 9).

5.2 Mounting the Q-545 on a Surface and Connecting It to a Protective Earth Conductor

NOTICE

Protruding screw heads!

Protruding screw heads can damage the Q-545.

- ➢ Ensure that the screw heads do not protrude from countersunk holes so that they do not interfere with the stage motion.

NOTICE

Warping of the Q-545 due to mounting on uneven surfaces!

Mounting the Q-545 on an uneven surface can warp the Q-545. Warping reduces the accuracy.

- ➢ Mount the Q-545 on an even surface. The recommended evenness of the surface is ≤2 µm.
- ➢ For applications with large temperature changes:
  Only mount the Q-545 on surfaces that have the same or similar thermal expansion properties as the Q-545.

INFORMATION

The electrical contact of the Q-545 to the protective earth conductor is established via the surface, on which the Q-545 is mounted.

- The corresponding contact surfaces must be sufficiently conductive.
- The protective earth conductor is connected to the surface on which the Q-545 is mounted.
- The screws are secured against unintentional loosening; e.g., with threadlocker.

INFORMATION

➢ Observe the applicable standards for mounting the protective earth conductor.

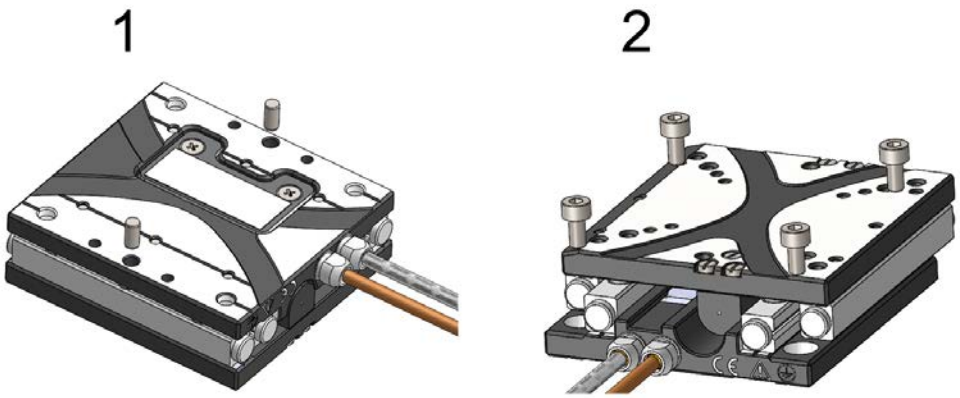


Figure 6: Example Q-545.140, left: View from below; right: View from top

1 Two locating holes on the bottom side of the stage are used for alignment on a surface.

2 The stage is mounted on a surface using four M2.5 screws.

Prerequisites

✓ You have read and understood the general notes on installation (p. 21).

✓ The Q-545 is disconnected from the electronics.

✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws and locating pins, see "Dimensions" (p. 65)):

– The surface must be connected to the protective earth conductor.

- Two locating holes with ∅2.5 mm H7 and four M2.5 mounting holes are available in the surface.
- The contact surfaces to the bottom side of the stage have to be sufficiently conductive to ensure the proper functioning of the protective earth conductor.
- For applications with large temperature changes: The surface should have the same thermal expansion properties as the Q-545 (e.g., surface made of aluminum).
- The evenness of the surface is ≤2 µm.

✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories

- 5861500010 screw set from the scope of delivery of the Q-545 (p. 12):
  - 2 dowel pins 2.5 m6 x 5 ISO 8734, for use as locating pins
  - 4 socket head cap screws M2.5x5 ISO 4762
- Suitable tools for fastening the screws
- Threadlocker

Mounting the Q-545 on a surface and connecting it to a protective earth conductor

1. Align the Q-545 on the surface using the locating pins:
   a) Introduce the two locating pins into the locating holes on the bottom side of the Q-545 (see figure above) or in the surface.
   b) Place the Q-545 on the surface so that the locating pins are inserted into the corresponding locating holes on the other side.
2. Mount the Q-545 on the surface using four M2.5 screws.
   a) Manually displace the moving platform of the Q-545 until two of the four countersunk holes in the base body are accessible.
   b) Insert a screw into each of the two countersunk holes.
   c) Tighten the screws with a maximum torque of 72 Ncm each.
   d) Make sure that the screw heads do not protrude from the countersunk holes.
   e) Repeat the steps a) to d) for the other two countersunk holes in the base body of the Q-545.
3. Secure the screws against unintentional loosening; e.g., with threadlocker.

4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is <0.1 Ω at 25 A.
5. Check that the Q-545 is affixed firmly to the surface.

5.3 Setting Up a Multi-Axis System

The Q-545 can be used in multi-axis systems.

Typical combinations:

- XY system (p. 27)
- Z system (p. 30) (XZ or XYZ combination)

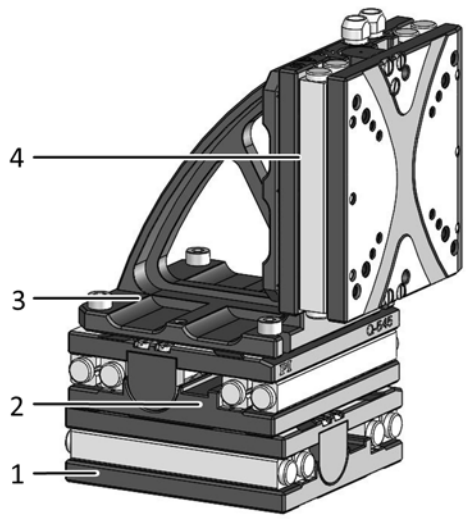


Figure 7: Example for an XYZ system: Three Q-545.140 mounted using an adapter bracket

1 Lower stage
2 Middle stage
3 Q-145.1001 adapter bracket (use in a vacuum to 10^{-6} hPa)
4 Upper stage

5.3.1 General Information on Setting Up a Multi-Axis System

NOTICE

Impermissibly high load on the stages!

In a multi-axis system, the stage used for the Y and/or Z axis must also be moved. Impermissibly high loads impair the motion and can damage the stages.

- Include the masses of the moved stages and of the adapter bracket (p. 13) in the calculation of the load to be moved.
- For all stages in a multi-axis system: Do **not** exceed the maximum permissible load.
- If a stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.

5.3.2 Setting Up an XY System

NOTICE

Screws and locating pins that are too long!

Screws and locating pins that are inserted too deeply damage the Q-545.

- Observe the depth of the mounting holes (p. 65) in the moving platform.
- Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- Only use screws and locating pins of the correct length for the respective holes.

INFORMATION

Any model of the Q-545 can be used as lower or upper stage.

Designations in these instructions:

- **Lower stage**: Forms the basis of the multi-axis system (X axis); is mounted on a surface
- **Upper stage**: Forms the Y axis of the multi-axis system; is mounted on the lower stage rotated by 90°

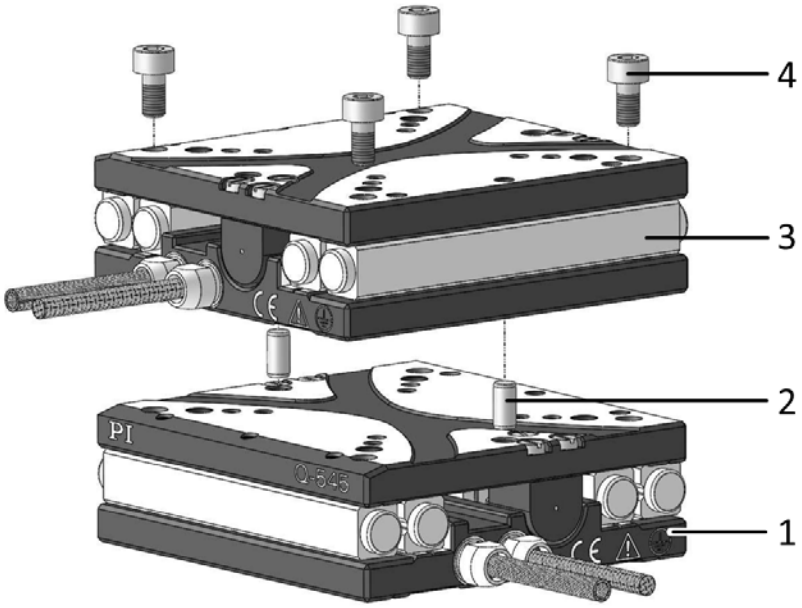


Figure 8: Example: Mounting a Q-545.140 on a Q-545.140

1 Lower stage
2 2 dowel pins 2.5 m6 x 5 ISO 8734; for use as locating pins
3 Upper stage
4 4 socket head cap screws M2.5x5 ISO 4762

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ The stages are disconnected from the electronics.
- ✓ You have properly mounted the lower stage on a surface and connected it to a protective earth conductor (p. 23).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories

- 5861500010 screw set from the scope of delivery of the Q-545 (p. 12):
  - 2 dowel pins 2.5 m6 x 5 ISO 8734; for use as locating pins
  - 4 socket head cap screws M2.5x5 ISO 4762
- Suitable tools for fastening the screws

Setting up an XY system

1. Insert the two locating pins into the locating holes on the bottom side of the upper Q-545 or in the moving platform of the lower Q-545 (see figure above).
2. Place the upper Q-545 on the lower Q-545 so that the locating pins are inserted into the corresponding locating holes on the other side.
3. Mount the upper Q-545 to the lower Q-545 using four M2.5 screws:
   a) Manually displace the moving platform of the upper Q-545 until two of the four countersunk holes in the base body are accessible.
   b) Insert a screw into each of the two countersunk holes.
   c) Tighten the screws with a maximum torque of 72 Ncm each.
   d) Make sure that the screw heads do not protrude from the countersunk holes.
   e) Repeat steps a) to d) for the other two countersunk holes in the base body of the upper Q-545.
4. Check that the upper Q-545 is affixed firmly to the lower Q-545.

5.3.3 Setting Up a Z System with an Adapter Bracket

NOTICE

Inserting screws and locating pins too deeply!

Screws and locating pins that are inserted too deeply damage the Q-545.

- ➢ Observe the depth of the mounting holes (p. 65) in the moving platform.
- ➢ Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- ➢ Only use screws and locating pins of the correct length for the respective holes.

Observe the following order when you align the adapter bracket on the lowerstage:

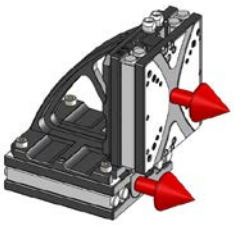
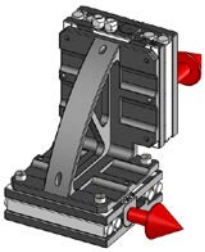
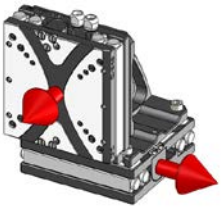
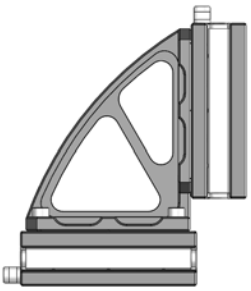
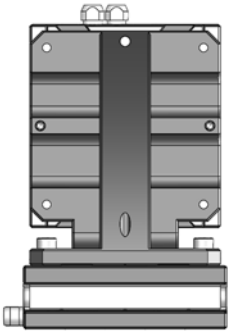
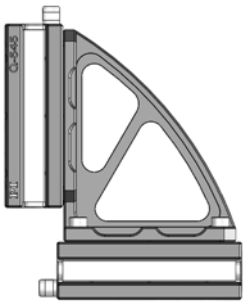
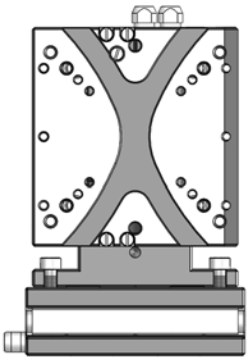
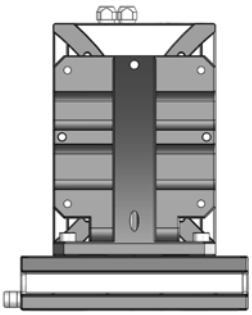
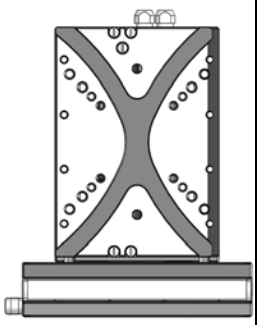
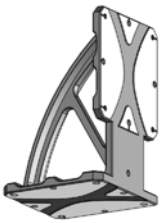
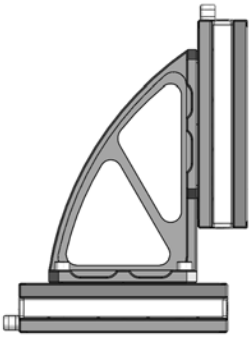
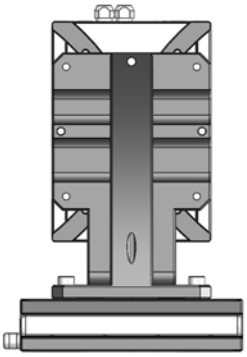
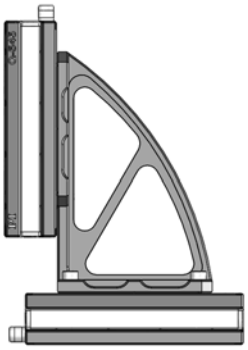
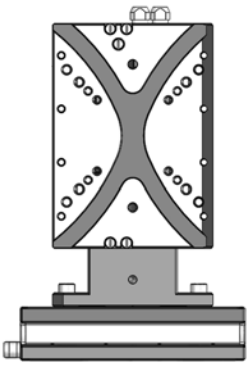
1. Insert the locating pins into the short side of the adapter bracket **from below**.
2. Make sure that the locating pins are inserted **up to the limit stop**.
3. Place the adapter bracket on the moving platform of the lower stage.

Designations in these instructions:

- **Lower stage**: X axis in an XZ combination; Y axis in an XYZ combination. The stage to which the upper stage is mounted with an adapter bracket.
- **Upper stage**: Forms the Z axis of the multi-axis system; is mounted on the lower stage in a vertical alignment using an adapter bracket.

Recommended Z Systems

The following combinations of adapter brackets and stages are recommended:

	Orientation of adapter bracket and upper stage to the lower stage:			
Combination of stages and adapter bracket:	0° 	90° 	180°	270° 
2 Q-545.1xx + Q-145.1001 or Q-145.10U1				
2 Q-545.2xx + Q-145.1001 or Q-145.10U1	Not possible. The moving platforms of the stages collide with each other.		Not possible. The moving platforms of the stages collide with each other.	
2 Q-545.2xx +  Q-145.200 or Q-145.20U				

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 27).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.
- ✓ If you set up an XZ combination: You have properly mounted the lower stage on a surface.
- ✓ If you set up an XYZ combination: You have properly mounted the stages for the X and Y axis. (p. 27)

Tools and accessories

- Suitable adapter bracket; for combination options, see "Recommended Z Systems" (p. 30). The following brackets are available as optional accessory (p. 13):
  - For Z systems suitable for use in a vacuum to 10^{-6} hPa: Q-145.1001 or Q-145.200 adapter bracket.
  - For Z systems suitable for use in a vacuum to 10^{-9} hPa: Q-145.10U1 or Q-145.20U adapter bracket.

  For the diameter and position of the holes in the adapter bracket, see "Dimensions" (p. 65)
- Mounting accessories from the scope of delivery of the adapter bracket:
  - 2 dowel pins 2.5 m6 x 4, for use as locating pins
  - 4 socket head cap screws M2.5x8
- Mounting accessories from the scope of delivery of the stage (p. 12):
  - 2 dowel pins 2.5 m6 x 5, for use as locating pins
  - 4 socket head cap screws M2.5x5
- Allen wrench AF 2

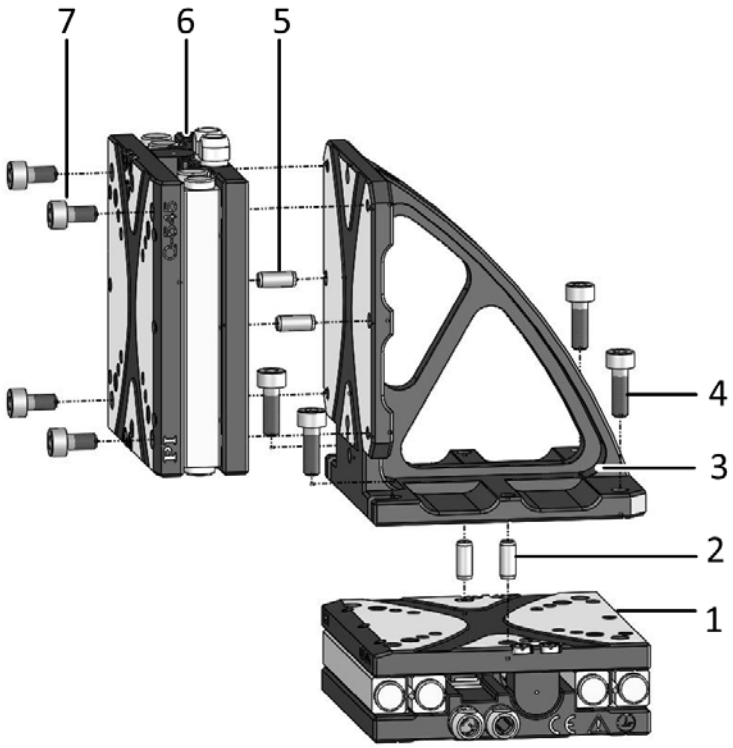


Figure 9: Example: Setting up an XZ system consisting of two Q-545.140 and a Q-145.200 or Q-145.20U adapter bracket

1 *Lower stage*
2 *2 dowel pins 2.5 m6 x 4 for use as locating pins; from the scope of delivery of the adapter bracket*
3 *Q-145.200 adapter bracket (for operation in a vacuum to 10^{-6} hPa) or Q-145.20U (for operation in a vacuum to 10^{-9} hPa)*
4 *4 socket head cap screws M2.5x8 for mounting the adapter bracket on the lower stage, from the scope of delivery of the adapter bracket*
5 *2 dowel pins 2.5 m6 x 5 for use as locating pins, from the scope of delivery of the stage*
6 *Upper stage*
7 *4 socket head cap screws M2.5x5 for mounting the upper stage on the adapter bracket, from the scope of delivery of the stage*

Figure 10: Adapter bracket with screws and locating pins. The locating pins for alignment on the lower stage must be inserted into the bracket from below and up to the limit stop.

Setting up a Z system

1. Mount the upper stage to the long side of the adapter bracket:
   a) Align the upper stage so that the cable exit points away from the origin of the sides of the adapter bracket; i.e., upwards in the Z system.
   b) Insert the 2.5 m6 x 5 locating pins into the locating holes on the bottom of the upper stage or in the long side of the adapter bracket.
   c) Place the stage on the long side of the adapter bracket so that the locating pins are inserted into the corresponding locating holes on the other side.
   d) Mount the stage using four M2.5x5 screws according to step 3 of the instructions in "Setting up an XY System" (p. 27).
2. Mount the short side of the adapter bracket to the moving platform of the lower stage:
   a) Insert the 2.5 m6 x 4 locating pins into the locating holes in the short side of the adapter bracket from below and up to the limit stop (see figure above).

b) If you set up a Z system consisting of a Q-145.1xx adapter bracket and two Q-545.2xx stages: Align the adapter bracket so that the moving platforms of the stages **cannot** collide with each other; for permissible orientations, refer to "Recommended Z Systems" (p. 30).
c) Place the short side of the adapter bracket on the moving platform of the lower stage so that the locating pins are inserted into the corresponding locating holes in the platform.
d) Insert four M2.5x8 screws into the mounting holes of the adapter bracket.
e) Tighten the screws with a maximum torque of 72 Ncm each.

3. Check that the adapter bracket and the upper stage are affixed firmly.

5.4 Affixing the Load to the Q-545

NOTICE

Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the moving platform can damage the Q-545.

- ➢ For affixing type and mass of the load, observe the maximum permissible forces according to the specifications (p. 61).
- ➢ Avoid tilting torques at the moving platform.

NOTICE

Screws and locating pins that are too long!

Screws and locating pins that are inserted too deeply damage the Q-545.

- ➢ Observe the depth of the mounting holes (p. 65) in the moving platform.
- ➢ Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- ➢ Only use screws and locating pins of the correct length for the respective holes.

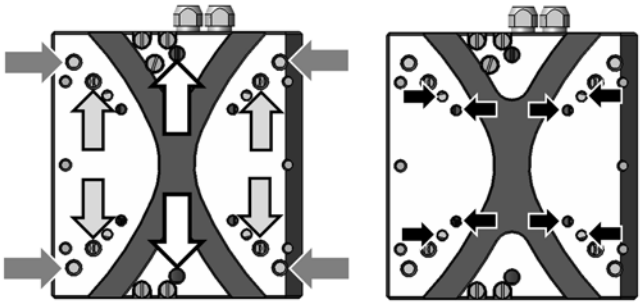


Figure 11: Q-545.14x

The arrows mark the following mounting holes in the moving platform of the Q-545.1xx:

For aligning the load:	
White arrows:	*Locating holes Ø 2.5 mm H7, depth 2.5 mm*
For affixing the load:	
Dark-gray arrows:	*M2.5 threaded holes, depth 5 mm*
Light-gray arrows:	*M2.5 threaded holes, depth 4 mm*
Black arrows:	*M2 threaded holes, depth 4 mm*

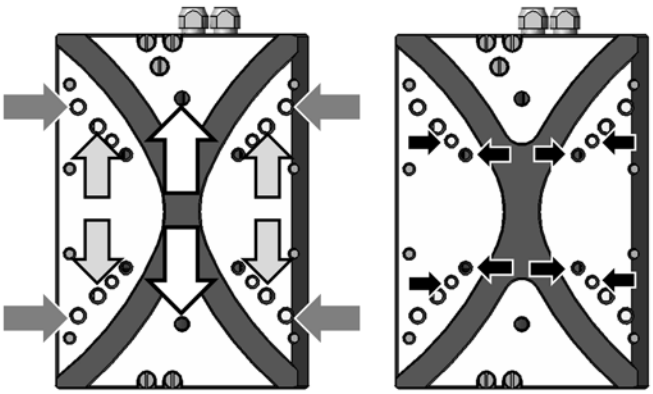


Figure 12: Q-545.24x

The arrows mark the following mounting holes in the moving platform of the Q-545.2xx:

For aligning the load:	
White arrows:	*Locating holes Ø 2.5 mm H7, depth 1.4 mm*
For affixing the load:	
Dark-gray arrows:	*M2.5 threaded holes, depth 4 mm*
Light-gray arrows:	*M2.5 threaded holes, depth 4 mm*
Black arrows:	*M2 threaded holes, depth 4 mm*

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have properly mounted the stage on a surface (p. 23) or on a Q-545 (p. 26).
- ✓ The stage is disconnected from the electronics.
- ✓ You have prepared the load so that it can be affixed to the moving platform (for the required position and depth of the holes for accommodating the screws and locating pins, see "Dimensions" (p. 65)):
  - The distance between the center of gravity of the load and the center of the moving platform is as small as possible in all directions.
  - Four points are provided for affixing the load to the moving platform.
  - If you use locating pins for aligning the load: You have made two locating holes of Ø 2.5 mm H7 in the load for accommodating locating pins.

Tools and accessories

- Screws of suitable length (p. 65). Options:
  - M2 screws
  - M2.5 screws
- Suitable tools for fastening the screws
- Optional: 2 locating pins of suitable length, for locating holes with Ø 2.5 mm H7

Affixing the load to the Q-545

1. Align the load on the Q-545 so that the mounting holes in the load and the holes in the moving platform overlap.

   If you use locating pins to align the load:

   a) Insert the locating pins into the locating holes in the moving platform or in the load.
   b) Place the load on the moving platform so that the locating pins are inserted into the corresponding locating holes on the other side.

2. Affix the load using the screws.
   - Maximum torque for M2 screws: 35 Ncm
   - Maximum torque for M2.5 screws: 72 Ncm
3. Check that the load is affixed firmly to the moving platform of the stage.

5.5 Connecting the Q-545 to the Electronics

The electronics to be used for operating the Q-545 depends on the presence of a sensor (see also "Suitable Electronics" (p. 15)):

- Models without sensor (Q-545.x0x): E-870 drive electronics (p. 38)
- Models with sensor (Q-545.x4x): E-871 (p. 42) controller

INFORMATION

The Q-545 and the electronics can be delivered as a pre-configured system.

➢ If a connection assignment is given on the labels of the Q-545 and/or electronics, observe this assignment when connecting the Q-545.

5.5.1 Connecting the Q-545 to the Drive Electronics

Prerequisites

✓ You have read and understood the general notes on installation.

✓ You have installed the E-870 drive electronics (p. 15).

✓ You have read and understood the user manual of the drive electronics.

✓ The drive electronics are switched off; i.e., **not** connected to the power source.

Tools and accessories

- If the drive electronics have a Mini-DIN 4 socket (models: E-870.x1, E-870.xG): 7202500042-0015 adapter cable, in the scope of delivery (p. 12)
- If the drive electronics have a connector strip (model E-870.10): Suitable adapter from Sub-D 15 (f) to the connector strip:
  - The pin assignment of the J10 connector strip (2x4 pin) can be found in the E870T0001 Technical Note.
  - If you need a suitable adapter, contact our customer service department (p. 59).
- If a Q-545.x0U is to be operated at atmospheric pressure: 5604500041 adapter, in the scope of delivery (p. 12)
- If the Q-545 is to be operated in a vacuum:

- E-873.UHVx extension cable, available as optional accessory (p. 13)
- Suitable vacuum feedthrough, available as optional accessory (p. 13):
  For Q-545.x00: C-815.VF
  For Q-545.x0U: C-815.VFUx
- Suitable tools for installing the vacuum feedthrough

Connecting the Q-545.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation at atmospheric pressure

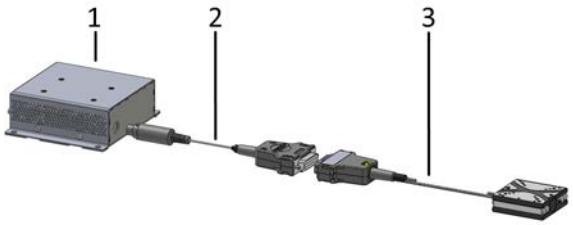


Figure 13: Connection diagram for Q-545.x00 and drive electronics with Mini-DIN 4 socket, for operation at atmospheric pressure

1 Drive electronics with Mini-DIN 4 socket (here E-870.xG)
2 7202500042-0015 adapter cable
3 Q-545.x00

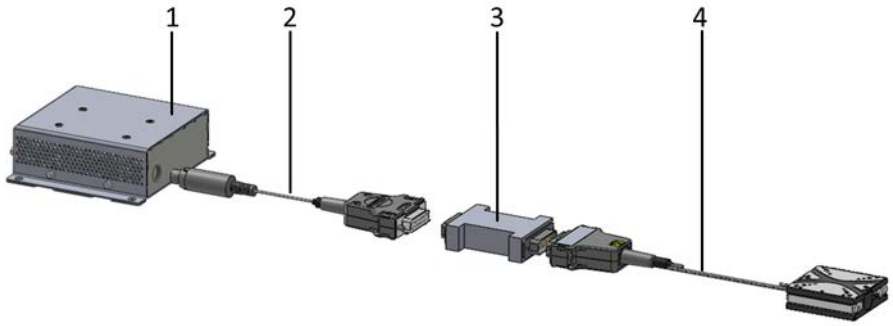


Figure 14: Connection diagram for Q-545.x0U and drive electronics with Mini-DIN 4 socket, for operation at atmospheric pressure

1 Drive electronics with Mini-DIN 4 socket (here E-870.xG)
2 7202500042-0015 adapter cable
3 5604500041 adapter
4 Q-545.x0U

1. Q-545.x0U only: Connect the Sub-D 15 (f) connector with the 5604500041 adapter.
2. Connect the Q-545 with the adapter cable:
   - Q-545.x00: Connect the Sub-D 15 (m) connector of the Q-545 with the Sub-D 15 (f) connector of the adapter cable.
   - Q-545.x0U: Connect the free Sub-D 15 (m) connector side of the 5604500041 adapter with the Sub-D 15 (f) connector of the adapter cable.
3. Connect the adapter cable with the drive electronics:
   - Connect the Mini-DIN 4 connector of the adapter cable with the Mini-DIN 4 socket of the drive electronics.
4. Take suitable measures to secure the connections against accidental disconnection.

Connecting the Q-545.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation in a vacuum

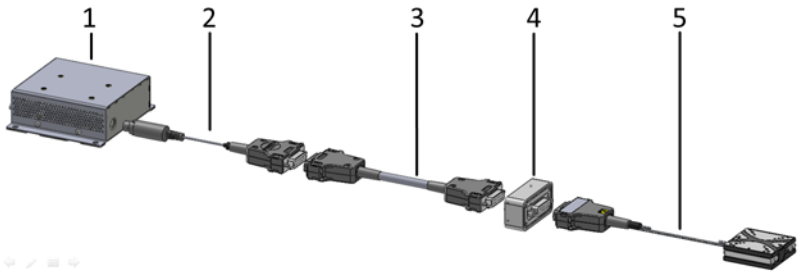


Figure 15: Connection diagram for Q-545.x00 and drive electronics with Mini-DIN 4 socket, for operation in a vacuum to 10^{-6} hPa

1 Drive electronics with Mini-DIN socket (here E-870.xG)
2 7202500042-0015 adapter cable
3 E-873.UHVx extension cable
4 C-815.VF vacuum feedthrough
5 Q-545.x00

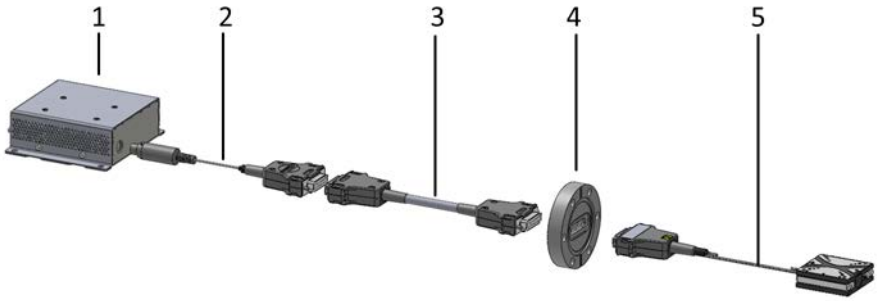


Figure 16: Connection diagram for Q-545.x0U and drive electronics with Mini-DIN 4 socket, for operation in a vacuum to 10^{-9} hPa

1 Drive electronics with Mini-DIN socket (here E-870.xG)
2 7202500042-0015 adapter cable
3 E-873.UHVx extension cable
4 C-815.VFUx vacuum feedthrough (here C-815.VFU1)
5 Q-545.x0U

1. Before connecting for the first time: Install the vacuum feedthrough:
   a) Obtain the dimensions from the corresponding dimensional drawing (p. 71).
   b) Make sure that the vacuum feedthrough is oriented correctly:
   C-815.VF: Vacuum side = Sub-D 15 (f) socket
   C-815.VFUx: See dimensional drawing (p. 71)
   c) Provide a suitable opening for the vacuum chamber.
   d) Install the vacuum feedthrough.
2. Connect the stage, vacuum feedthrough, cables, and drive electronics to each other as shown in the connection diagram above.
3. Take suitable measures to secure the connections against accidental disconnection.

Connecting the Q-545.x0x to E-870 drive electronics with connector strip

If a Q-545.x0x is to be operated at atmospheric pressure:

- Connect the Q-545.x0x to the connector strip of the drive electronics using a suitable adapter.

If a Q-545.x0x is to be operated in a vacuum:

1. Follow the instructions in "Connecting the Q-545.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation in a vacuum" to install the vacuum feedthrough and to connect the stage, vacuum feedthrough, and cables.
2. Connect the 7202500042-0015 adapter cable to the connector strip of the drive electronics using a suitable adapter.

5.5.2 Connecting the Q-545 to the Controller

Prerequisites

- ✓ You have read and understood the general notes on installation.
- ✓ You have installed the E-871 controller (p. 15).
- ✓ You have read and understood the user manual of the controller.
- ✓ The controller is switched off; i.e., the power supply is **not** connected to the power socket via the power cord.

Tools and accessories

- 7202500043-0015 Y adapter cable, in the scope of delivery (p. 12)
- If a Q-545.x4U is to be operated at atmospheric pressure: 5604500041 adapter, in the scope of delivery (p. 12)
- If the Q-545 is to be operated in a vacuum:
  - E-873.UHVx extension cable, available as optional accessory (p. 13)
  - Suitable vacuum feedthrough, available as optional accessory (p. 13):
    For Q-545.x40: C-815.VF
    For Q-545.x4U: C-815.VFUx
  - Suitable tools for installing the vacuum feedthrough

Connecting the Q-545.x4x to the E-871 controller for operation at atmospheric pressure

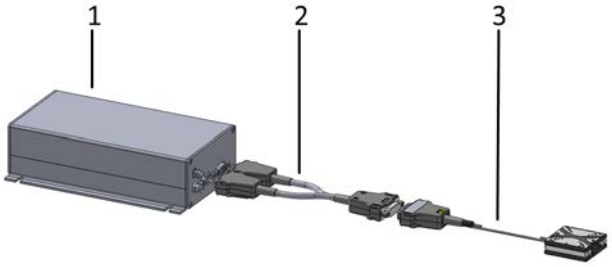


Figure 17: Connection diagram for Q-545.x40 and controller, for operation at atmospheric pressure

1 Controller (here E-871.1A1)
2 7202500043-0015 Y adapter cable
3 Q-545.x40

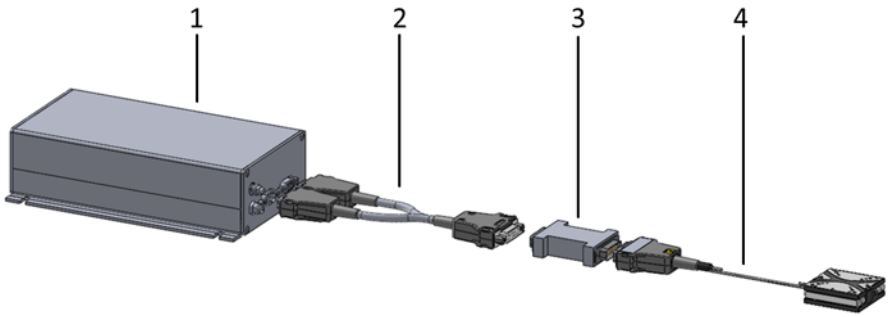


Figure 18: Connection diagram for Q-545.x4U and controller, for operation at atmospheric pressure

1 Controller (here E-871.1A1)
2 7202500043-0015 Y adapter cable
3 5604500041 adapter
4 Q-545.x4U

1. Remove the ESD protection from the Q-545:
   - Q-545.x40: Remove the ESD protective cap from the Sub-D 15 (m) connector.
   - Q-545.x4U: Remove the protective foil from the Sub-D 15 (f) connector.

2. Q-545.x4U only: Connect the Sub-D 15 (f) connector with the 5604500041 adapter.
3. Connect the Q-545 with the Y adapter cable:
   - Q-545.x40: Connect the Sub-D 15 (m) connector of the Q-545 with the Sub-D 15 (f) connector of the Y adapter cable.
   - Q-545.x4U: Connect the free Sub-D 15 (m) connector side of the 5604500041 adapter to the Sub-D 15 (f) connector of the Y adapter cable.
4. Connect the Y adapter cable with the E-871 controller:
   a) Connect the HD Sub-D 15 (m) connector for motor connection to the corresponding socket of the controller (see user manual of the controller).
   b) Connect the HD Sub-D 15 (f) connector for sensor connection with the corresponding panel plug of the controller (see user manual of the controller).
5. Secure the connections with the integrated screws against accidental disconnection.

Connecting the Q-545.x4x to the E-871 controller for operation in a vacuum

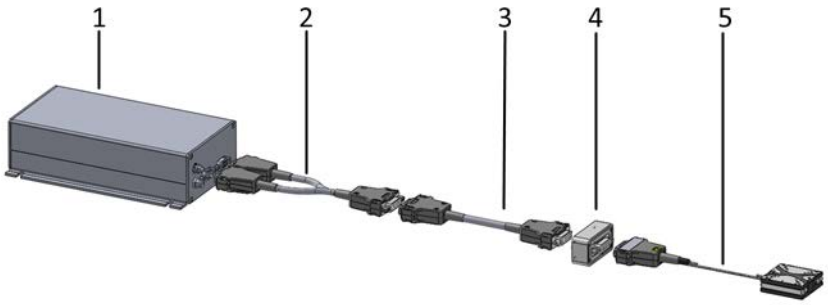


Figure 19: Connection diagram for Q-545.x40 and controller, for operation in a vacuum to 10^{-6} hPa

1 Controller (here E-871.1A1)
2 7202500043-0015 Y adapter cable
3 E-873.UHVx extension cable
4 C-815.VF vacuum feedthrough
5 Q-545.x40

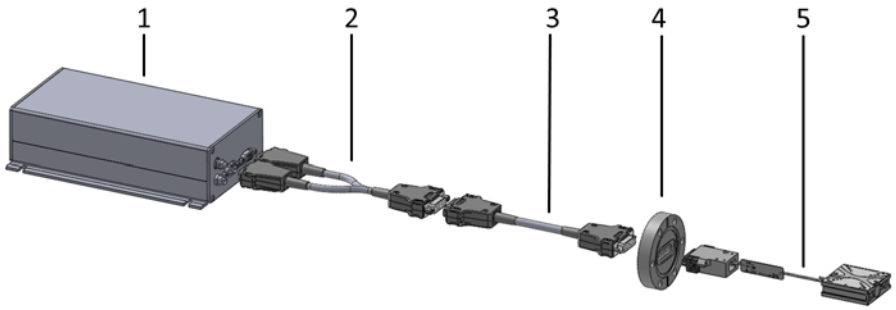


Figure 20: Connection diagram for Q-545.x4U and controller, for operation in a vacuum to 10^{-9} hPa

1 Controller (here E-871.1A1)
2 7202500043-0015 Y adapter cable
3 E-873.UHVx extension cable
4 C-815.VFUx vacuum feedthrough (here C-815.VFU1)
5 Q-545.x4U

1. Before connecting for the first time: Install the vacuum feedthrough:
   a) Obtain the dimensions from the corresponding dimensional drawing (p. 71).
   b) Make sure the vacuum feedthrough is oriented correctly:
   C-815.VF: Vacuum side = Sub-D 15 (f) socket
   C-815.VFUx: See dimensional drawing (p. 71).
   c) Provide a suitable opening for the vacuum chamber.
   d) Install the vacuum feedthrough.
2. Remove the ESD protection from the Q-545:
   – Q-545.x40: Remove the ESD protective cap from the Sub-D 15 (m) connector.
   – Q-545.x4U: Remove the protective foil from the Sub-D 15 (f) connector.
3. Connect the stage, vacuum feedthrough, cables, and controller as shown in the connection diagram above.
4. Secure the connections with the integrated screws against accidental disconnection.

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation 47
Starting Up the Stage 50

6.1 General Notes on Start-Up and Operation

CAUTION

Risk of electric shock if the protective earth conductor is not connected!

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the Q-545 in the case of malfunction or failure of the system. If touch voltages exist, touching the Q-545 can result in minor injuries from electric shock.

- Connect the Q-545 to a protective earth conductor (p. 23) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the Q-545 to the protective earth conductor before starting it up again.

CAUTION

Burning from hot surface!

The surface of the Q-545 and its vicinity can heat up during operation. Touching the Q-545 and surrounding parts can result in minor injuries from burning.

- Cool the Q-545 so that the temperature of its surface and surrounding parts does **not** exceed 65 °C.
- If sufficient cooling is not possible: Make sure that the hot Q-545 and its surrounding parts **cannot** be touched.
- If sufficient cooling and protection against contact are not possible: Mark the danger zone in accordance with the legal regulations.

NOTICE

Overheating during continuous operation!

The highest velocity is achieved at maximum operating frequency; however, the Q-545 can overheat during continuous operation as a result.

- ➢ Observe the recommended operating time according to the operating frequency in step mode (p. 64).
- ➢ Ensure sufficient ventilation at the place of installation.

NOTICE

Damage from collisions!

Collisions can damage the stage, the load to be moved and the environment.

- ➢ Make sure that no collisions are possible between the stage, the load to be moved and the environment in the motion range of the stage.
- ➢ Do not place any objects in areas where they can get caught by moving parts.
- ➢ Stop the motion immediately if an electronics malfunction occurs.

NOTICE

Operating frequency too high!

An operating frequency that is too high can cause damage to the Q-545.

- ➢ Only operate the Q-545 with controllers/drivers and original accessories from PI.
- ➢ Do **not** exceed the operating frequency range (p. 63) for which the Q-545 is specified.

NOTICE

Considerable wear due to high operating frequency!

A high operating frequency in step mode can cause considerable wear on the mechanical system.

- When the E-870 drive electronics are used:
  - If necessary, reduce the values of the parameters ***PIShift Steps per Second*** (ID 0x1F000600) and ***PIShift Frequency*** (ID 0x1F000400) on the drive electronics, see documentation of the drive electronics.
- When the E-871 controller is used:
  - When the ***PIShift Open-Loop Driving Mode*** (ID 0x1F000702) parameter has a value of 0 (step mode) and motions in open-loop operation are initiated with the SMO command: The step frequency depends directly from the control value commanded with SMO and is limited by the value of the ***Maximum Motor Output*** (ID 0x9) parameter. If necessary, reduce the commanded control value and the value of the ***Maximum Motor Output*** parameter.
- Reduce the operating time with a high operating frequency (p. 64).
- Stop the motion immediately if an electronics malfunction occurs.

NOTICE

Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the Q-545.

- Only operate the Q-545 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 63) for which the Q-545 is specified.
- Only operate the Q-545 when the operating voltage is properly connected; see "Pin Assignment" (p. 76).

NOTICE

Reduced lifetime of the piezo actuator due to permanently high voltage!

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic of the stage.

- When the Q-545 is not used, switch off the electronics.

NOTICE

Destruction of the piezo actuators by electric flashovers!

Using the Q-545 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuators of the drive by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials (e.g. metal dust). In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- ➢ Avoid operating the Q-545 in environments that can increase the electrical conductivity.
- ➢ Only operate the Q-545 within the permissible ambient conditions and classifications (p. 63).
- ➢ For operation in vacuum below 0.1 hPa:
  Do **not** operate the Q-545 during evacuation.

NOTICE

Increased wear due to small working range!

Using a small working range permanently increases the wear in this area.

- ➢ If possible: Select another part of the travel range for the working range in regular intervals.

6.2 Starting Up the Stage

The electronics to be used for operating the Q-545 depends on the presence of a sensor (see also "Suitable Electronics" (p. 15)):

- Models without sensor (Q-545.x0x): E-870 drive electronics (p. 51)
- Models with sensor (Q-545.x4x): E-871 controller (p. 53)

INFORMATION

If the parameters of the electronics are not adapted to the Q-545 and the application (load, orientation of the Q-545), the Q-545 will either not move or not move satisfactorily.

- ➢ Only operate the Q-545 when the parameters of the electronics have been correctly set.
- ➢ Pay particular attention to the parameter settings for operating voltage and operating frequency.

INFORMATION

The PIShift drive develops noises in step mode. The noise development depends on the current step frequency.

6.2.1 Starting Up the Q-545.x0x with the E-870 Drive Electronics

INFORMATION

The values for the parameters of the E-870 drive electronics are listed in a table in this section.

For optimum drive performance, the values of the following parameters should be identical:

- ***PIShift Steps per Second*** (ID 0x1F000600)
- ***PIShift Frequency*** (ID 0x1F000400)

Prerequisites

- ✓ You have read and understood the general notes on start-up and operation (p. 47).
- ✓ You have read and understood the documentation of the E-870 drive electronics (E870T0001 Technical Note or E870T0002 Technical Note).
- ✓ You have properly installed (p. 21) the stage.
- ✓ The E-870 drive electronics have been properly installed and all connections on the E-870 have been set up (see E870T0001 Technical Note or E870T0002 Technical Note).

Starting up the Q-545.x0x with the E-870 drive electronics

1. Make sure that the parameters of the E-870 drive electronics have been set correctly; for values, see table below.
2. Provide the control signal required for operating the system. Details can be found in the E870T0001 or E870T0002 Technical Note.
3. If necessary: Adapt the ***PIShift Steps per Second*** parameter (ID 0x1F000600) and the ***PIShift Frequency*** parameter (ID 0x1F000400) to your application (see also "Operating Time" (p. 64)).

The following table lists the settings for the parameters of the E-870 drive electronics. Further information on the parameter settings is found in the "Operating Time" section (p. 64).

Parameter	Parameter in E-870 drive electronics	Value	Unit
Operating voltage, upper limit	***PIShift Upper Supply Voltage*** ID 0x1F000000	48	V
Operating voltage, lower limit	***PIShift Lower Supply Voltage*** ID 0x1F000100	0	V
Charging current for forward motion	***PIShift Forward Current*** ID 0x1F000200	0.6	A
Charging for backward motion	***PIShift Backward Current*** ID 0x1F000300	-0.6	A
Operating frequency in step mode	***PIShift Frequency*** ID 0x1F000400	20000	Hz
Duty cycle of the current source during the output of one period of the modified sawtooth signal in step mode	***PIShift Charge Cycle*** ID 0x1F000500	1	-
Number of steps the stage moves per second at the set operating frequency.	***PIShift Steps per Second*** ID 0x1F000600	20000	

6.2.2 Starting Up the Q-545.x4x with the E-871.1A1 Controller

INFORMATION

If you use the software included in the scope of delivery of the E-871 controller, the operating parameters can be loaded from the *PIMicosStages2.dat* stage database. The entries in the stage database are updated regularly.

➢ Download the PI Update Finder from the PI website (http://www.update.pi-portal.ws) and use it to update the *PIMicosStages2.dat* stage database on your PC.

For further information, see the user manual of the E-871 controller.

INFORMATION

For optimum drive performance in step mode, the ***Maximum Motor Output*** (ID 0x9) parameter in the *PIMicosStages2.dat* stage database takes a value of 15 kHz.

For further information, see "Operating Time" (p. 64) and user manual of the E-871 controller.

Prerequisites

- ✓ You have read and understood the general notes on start-up and operation (p. 47).
- ✓ You have properly installed (p. 21) the stage.
- ✓ You have read and understood the user manual of the controller.
- ✓ You have read and understood the manual of the PC software.
- ✓ The controller and the required PC software have been installed. All connections on the controller have been set up (see user manual of the controller).

Starting up the Q-545.x4x with the E-871 controller

1. Start up the stage (see E-871 user manual).
   The start-up comprises the following steps:
   - Selecting the stage type
   - Defining the reference point of the axis
   - Commanding of first motions for testing

2. If necessary: Adapt the ***Maximum Motor Output*** (ID 0x9) parameter to your application (also refer to "General Notes on Start-Up and Operation" (p. 47) and "Operating Time" (p. 64)).

   The E-871 user manual describes the start-up using the PIMikroMove program.

7 Maintenance

In this Chapter

General Notes on Maintenance 55
Performing a Maintenance Run 55
Cleaning the Q-545 55

7.1 General Notes on Maintenance

NOTICE

Damage due to improper maintenance!

Improper maintenance can lead to misalignment and failure of the Q-545.

- ➢ Only loosen screws according to the instructions in this manual.

7.2 Performing a Maintenance Run

The maintenance run must cover the entire travel range.

- ➢ Perform the maintenance run after every 10 million steps.

7.3 Cleaning the Q-545

Prerequisites

- ✓ You have disconnected the stage from the electronics.

Cleaning the stage

Only when the stage is **not** used in vacuum:

- ➢ When necessary, clean the surfaces of the stage with a cloth that is lightly dampened with a mild cleanser or disinfectant.

Only when the stage is used in vacuum:

- ➢ Only touch the stage with powder-free gloves.
- ➢ If necessary, wipe the stage clean.

8 Troubleshooting

Problem	Possible causes	Solution
Functional impairment after system modification	▪ Drive electronics or controller has been replaced ▪ The stage has been replaced	E-870 drive electronics from PI: ➢ Adapt the parameters of the drive electronics in the E-870 Control PC program to the Q-545 (see "Starting up the Q-545.x0x with the E-870 Drive Electronics" (p. 51) and Technical Note E870T0001 and/or E870T0002). E-871 controller from PI: ➢ Load the parameter set from the stage database that corresponds to the Q-545 model. ➢ If necessary: In the PIMikroMove PC program, set the parameters of the controller so that they correspond to the application (load, orientation) of the Q-545 model (see user manual of the controller).
No or limited motion	Cable not connected correctly or defective	➢ Check the connecting cable(s)
	Excessive load	➢ Reduce the load. Observe the information in the "Technical Data" section (p. 61). ➢ If the stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.
	Parameters of the drive electronics incorrectly set	➢ See the "Functional impairment after system modification" problem in this table.
	Operating voltage too low	➢ Provide an operating voltage of 48 V.
	Unfavorable operating frequency for step mode	➢ Adapt the operating frequency for the step mode (for details, see "Starting Up the Stage" (p. 50) and manual of the electronics used).
	Warped base body	➢ Mount the Q-545 on an even surface. The recommended evenness of the surface is 2 µm.

Problem	Possible causes	Solution
	Unfavorable load mounting	➢ Observe the maximum torque when affixing the load (p. 35). ➢ Keep the distance between the center of gravity of the load and the center of the moving platform as small as possible in all directions.
	Unsuitable ambient conditions	➢ Only operate the Q-545 in a clean environment and within the permissible ambient conditions (p. 63).
	Wear of the drive	➢ Replace the Q-545 and make sure that the operating parameters of the electronics are adapted to the stage.
	Drive is blocked	➢ Carefully release the blockage by manually moving the moving platform back and forth. ➢ Contact our customer service department (p. 59).
	During affixing of a load or an adapter bracket on the moving platform of the stage: Dowel pin was pushed too deeply into the moving platform	➢ Contact our customer service department (p. 59).

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 59).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

- If you have questions concerning your system, have the following information ready:
  - Product codes and serial numbers of all products in the system
  - Firmware version of the controller (if present)
  - Version of the driver or the software (if present)
  - Operating system on the PC (if present)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

In this Chapter

Specifications 61
Operating Time 64
Dimensions 65
Pin Assignment 76

10.1 Specifications

10.1.1 Data Table

Preliminary Data	Q-545.100 / Q-545.10U	Q-545.140 / Q-545.14U	Q-545.200 / Q-545.20U	Q-545.240 / Q-545.24U	Unit	Tolerance
Motion and Positioning						
	13 mm travel range, open-loop, UHV version Q-545.10U	13 mm travel range, resolution 1 nm, UHV version Q-545.14U	26 mm travel range, open-loop, UHV version Q-545.20U	26 mm travel range, resolution 1 nm, UHV version Q-545.24U		
Active axis	X	X	X	X		
Travel	13	13	26	26	mm	
Integrated sensor	-	Linear encoder	-	Linear encoder		
Sensor resolution	-	1	-	1	nm	
Min. incremental motion	500 (open-loop)	6	500 (open-loop)	6	nm	typ.
Unidirectional repeatability	-	0.018	-	0.018	µm	
Angular crosstalk	±50	±50	±80	±80	µrad	
Linear crosstalk	±1	±1	±2	±2	µm	

Preliminary Data	Q-545.100 / Q-545.10U	Q-545.140 / Q-545.14U	Q-545.200 / Q-545.20U	Q-545.240 / Q-545.24U	Unit	Tolerance
Maximum velocity	10	10	10	10	mm/s	min.
Reference point switch	-	Optical	-	Optical		
Mechanical Properties						
Load capacity	10	10	10	10	N	
Holding force, de-energized	8	8	8	8	N	min.
Push / pull force	8	8	8	8	N	typ.
Drive Properties						
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
Miscellaneous						
Operating temperature range	0 to 40	0 to 40	0 to 40	0 to 40	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Cable length	Q-545.100: 2 Q-545.10U: 1	Q-545.140: 2 Q-545.14U: 1	Q-545.200: 2 Q-545.20U: 1	Q-545.240: 2 Q-545.24U: 1	m	
Connector	Sub-D 15	Sub-D 15	Sub-D 15	Sub-D 15		
Recommended controller / driver	E-870	E-871, E-873	E-870	E-871, E-873		

The Q-545 stage series replaces the LPS-45 series.

The specifications were determined on a surface with an evenness of 2 µm.

10.1.2 Maximum Ratings

The Q-545 stage is designed for the following operating data:

Maximum operating voltage	**Maximum operating frequency**	**Maximum power consumption**
48 V	20 kHz	30 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the Q-545:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	Q-545.xx0: 1100 hPa to 10^{-6} hPa Q-545.xxU: 1100 hPa to 10^{-9} hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C, non-condensing Decreasing linearly to 50 % relative humidity at 40 °C, non-condensing
Operating temperature	0 °C to 40 °C
Storage temperature	-20 °C to 70 °C
Transport temperature	-20 °C to 70 °C
Maximum bakeout temperature for Q-545.xxU:	120 °C, for 12 hours, only in **switched-off** state
Maximum bakeout temperature for Q-545.xx0:	80 °C, for 2 hours, only in **switched-off** state
Overvoltage category (acc. to EN 60664-1:2007 / VDE 0110-1)	II

Protection class (acc. to EN 61140 / VDE 0140-1)	I
Degree of pollution (acc. to EN 60664-1:2007 / VDE 0110-1)	1
Degree of protection (acc. to IEC 60529)	IP20

10.2 Operating Time

The operating time and the operating frequency in step mode affect the lifetime of the stage. In order to prevent overheating and high wear, the operating time with the given operating frequency and 100 % duty cycle must not exceed the values given in the following table.

Operating frequency in Hz[1]	Operating time[2] / 48 V, ±0.6 A
20000	10 s (max.)
10000	20 s (max.)
5000	60 s (max.)
≤ 1000	120 s (max.)

[1] For the relevant parameters, see "Starting Up the Stage" (p. 50) and the user manual of the electronics used.

[2] With 100 % duty cycle without heat dissipation

10.3 Dimensions

10.3.1 Q-545.10x

Dimensions in mm

Characters used to separate decimal places:

- Depth and diameter of holes: Period
- All other dimensions: Comma

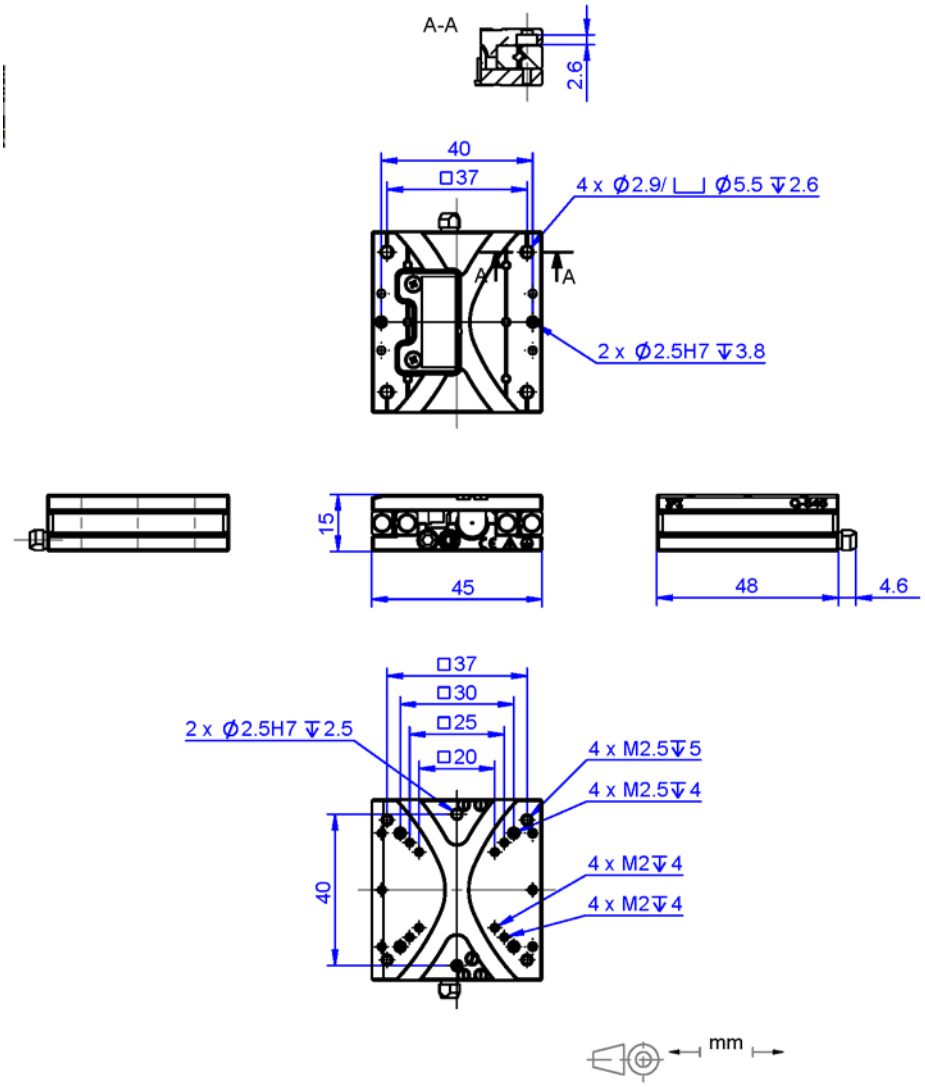


Figure 21: Q-545.10x

10.3.2 Q-545.14x

Dimensions in mm

Characters used to separate decimal places:

- Depth and diameter of holes: Period
- All other dimensions: Comma

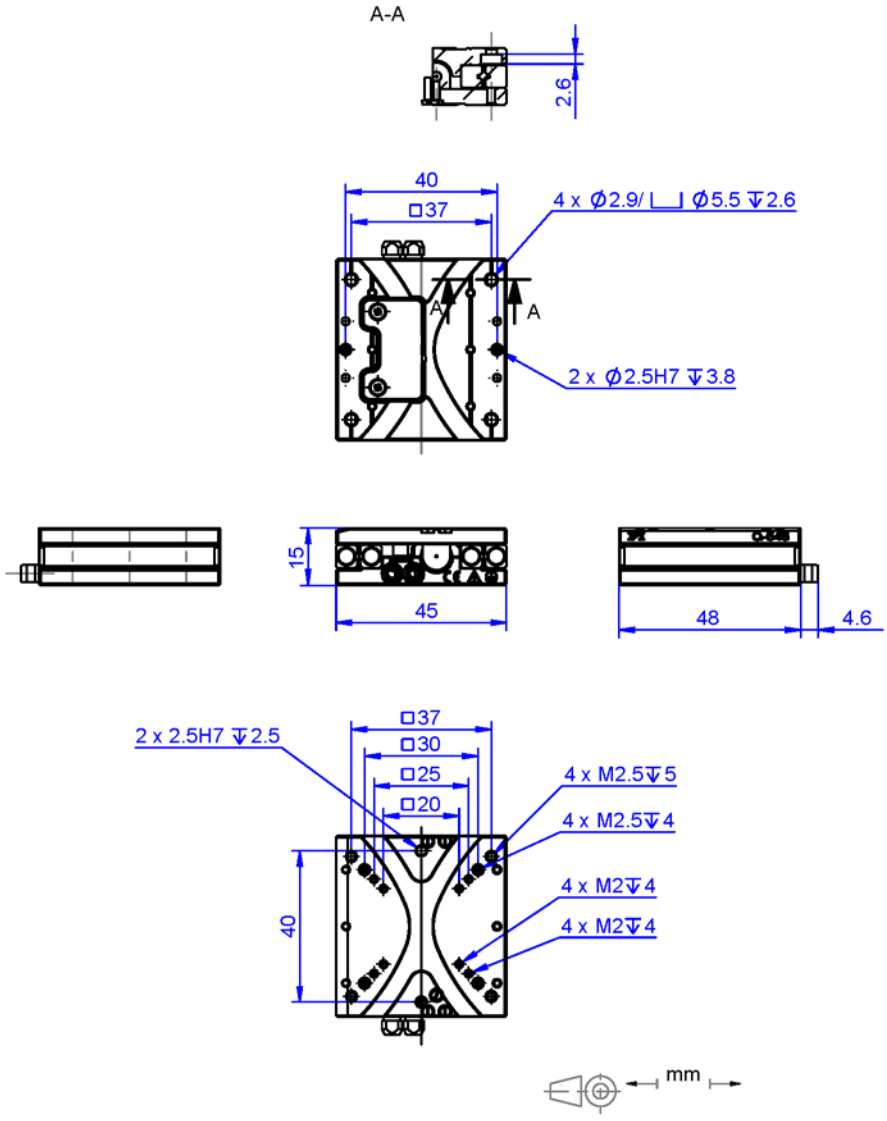


Figure 22: Q-545.14x

10.3.3 Q-545.20x

Dimensions in mm

Characters used to separate decimal places:

- Depth and diameter of holes: Period
- All other dimensions: Comma

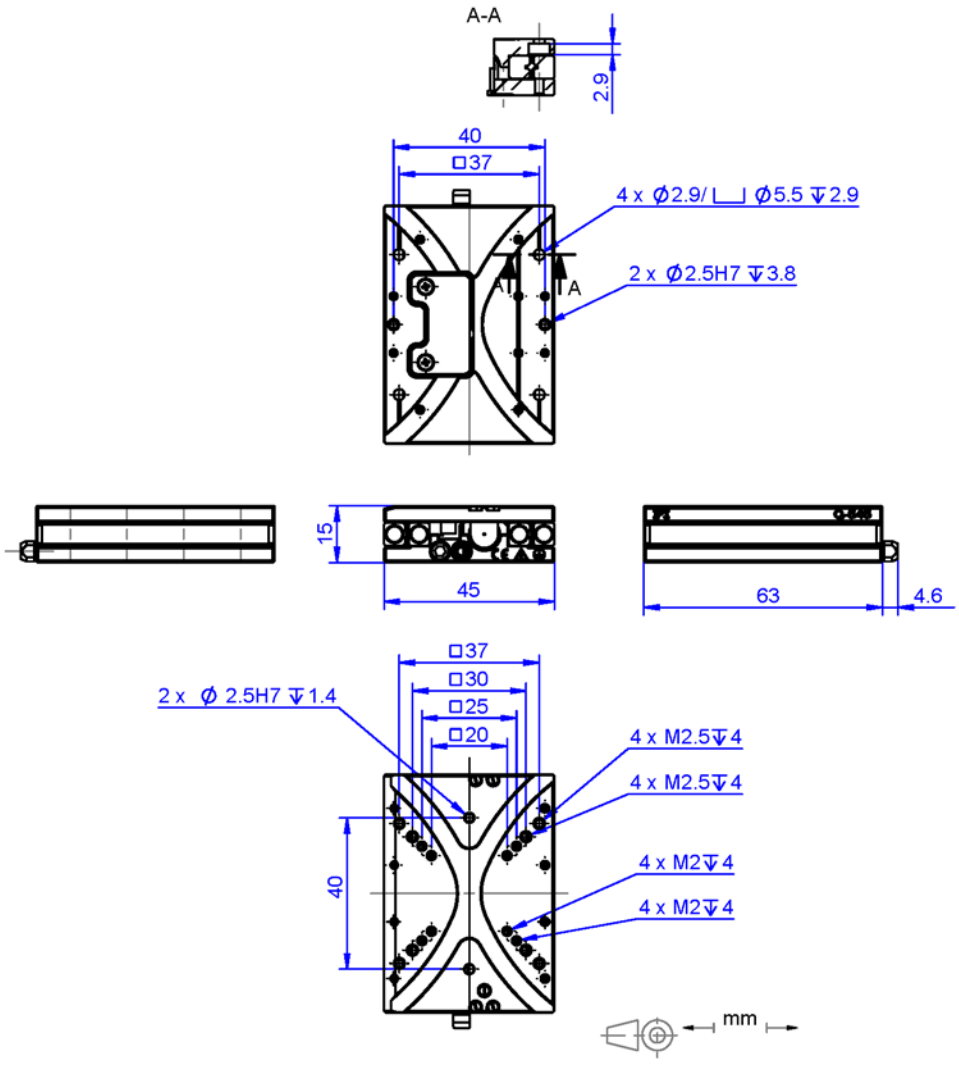


Figure 23: Q-545.20x

10.3.4 Q-545.24x

Dimensions in mm

Characters used to separate decimal places:

- Depth and diameter of holes: Period
- All other dimensions: Comma

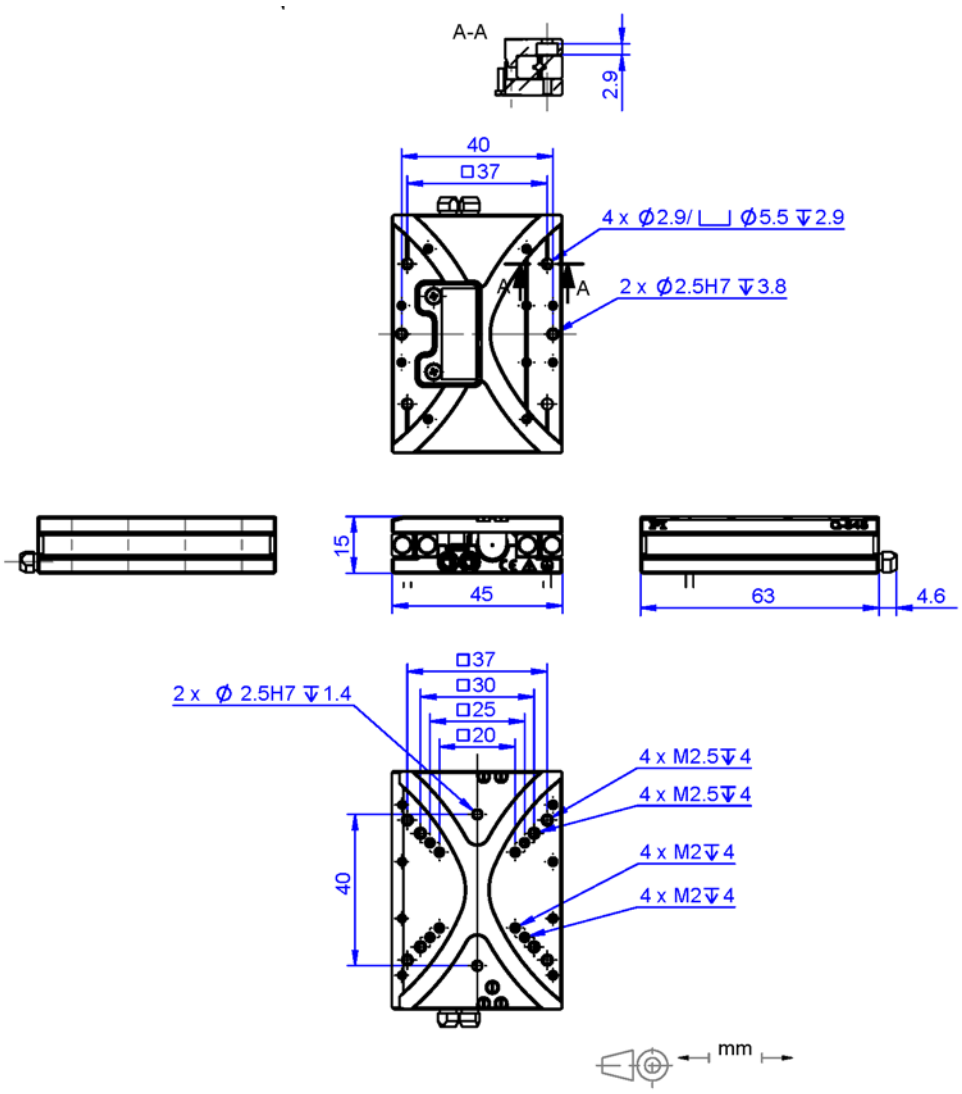


Figure 24: Q-545.24x

10.3.5 Q-145.1001 and Q-145.10U1 Adapter Brackets

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

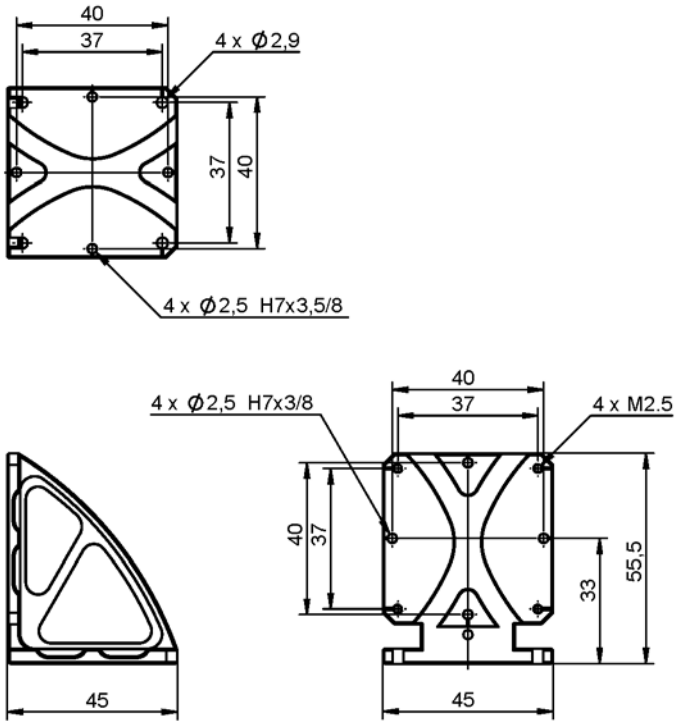


Figure 25: Q-145.1001 adapter bracket, dimensions of the Q-145.10U1 adapter bracket are identical

10.3.6 Q-145.200 and Q-145.20U Adapter Brackets

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

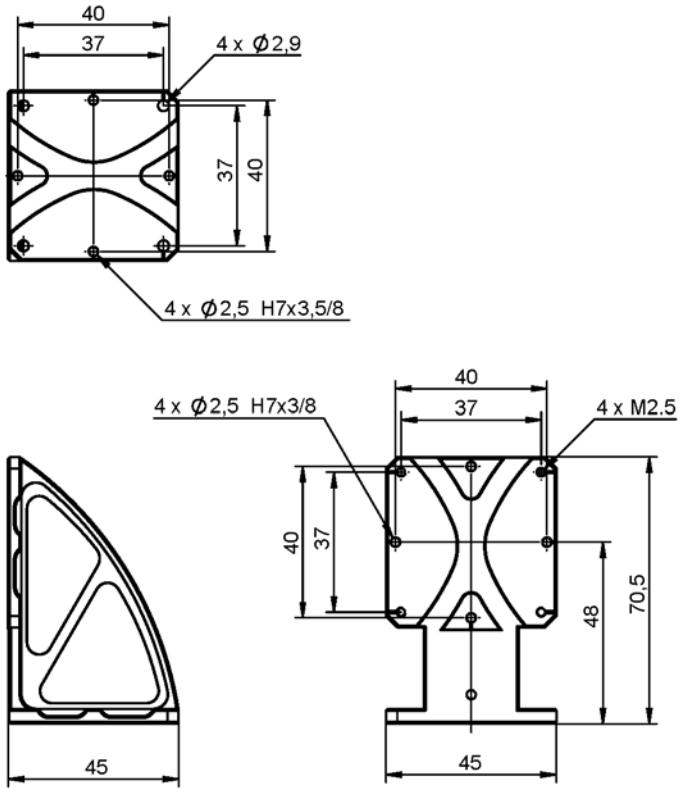


Figure 26: Q-145.200 adapter bracket, dimensions of the Q-145.20U adapter bracket are identical

10.3.7 Vacuum Feedthroughs

Available vacuum feedthroughs:

- C-815.VF (p. 71)
- C-815.VFU1 (p. 72)
- C-815.VFU3 (p. 73)
- C-815.VFU6 (p. 74)
- C-815.VFU15 (p. 75)

C-815.VF vacuum feedthrough for 10^{-6} hPa

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

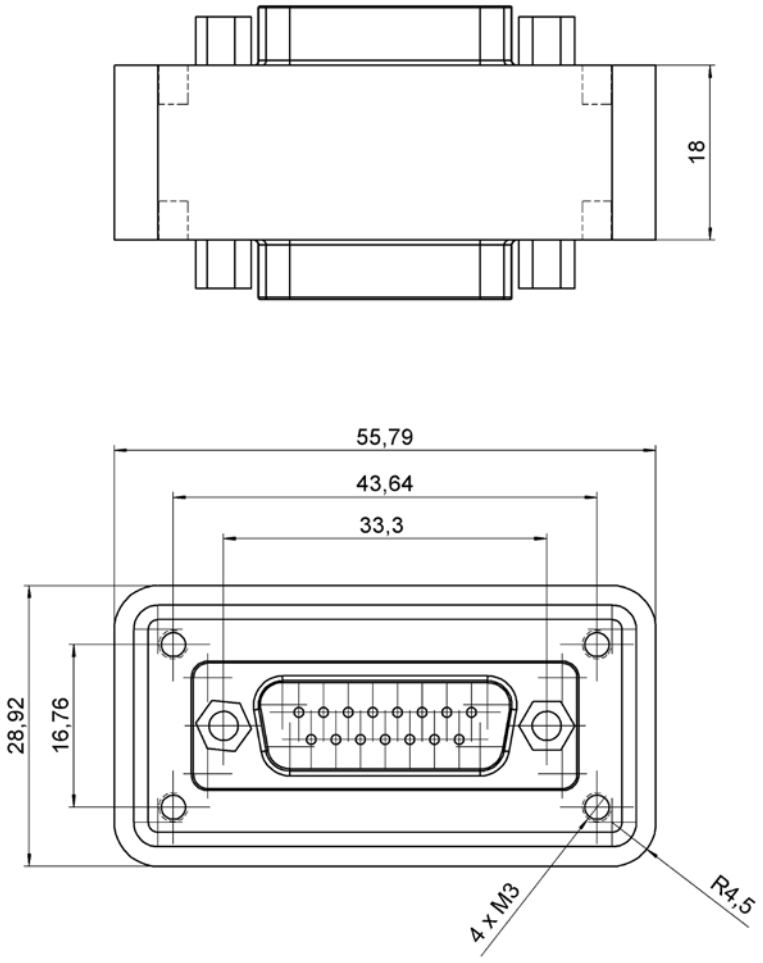


Figure 27: C-815.VF vacuum feedthrough Sub-D 15 (m/f)

C-815.VFU1 vacuum feedthrough for 10^{-9} hPa

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

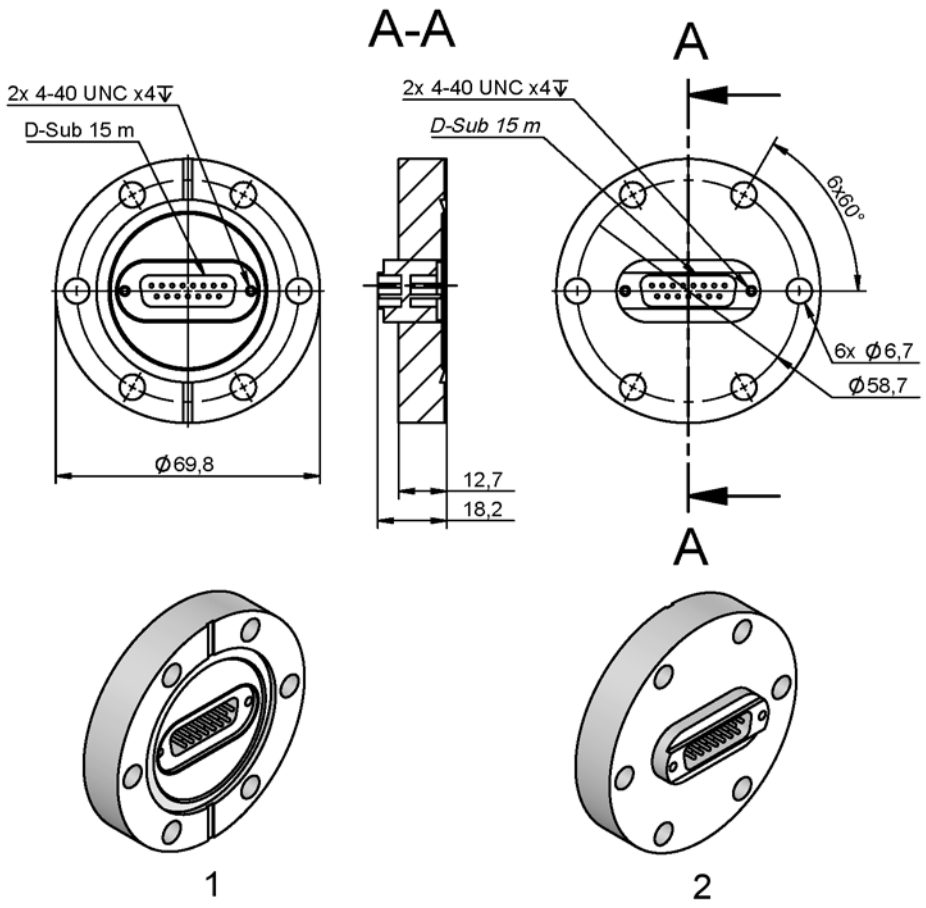


Figure 28: C-815.VFU1 vacuum feedthrough, Sub-D 15 (m/m)

1 Vacuum side

2 Air side

C-815.VFU3 vacuum feedthrough for 10^{-9} hPA

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

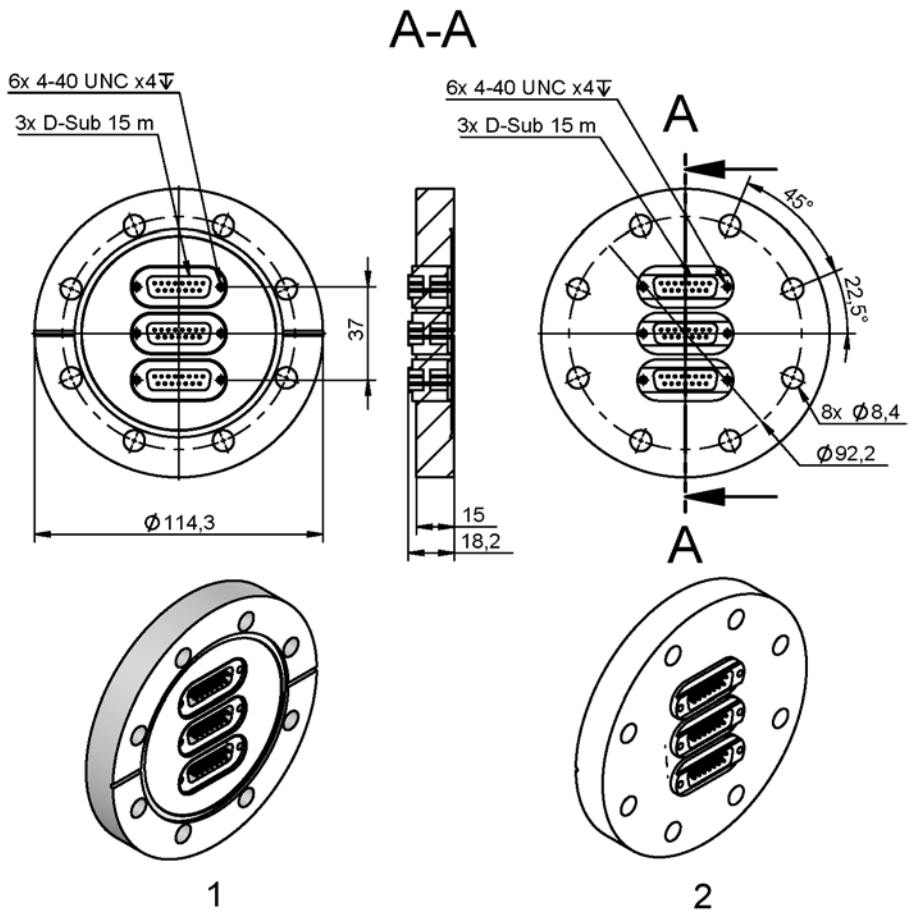


Figure 29: C-815.VFU3 vacuum feedthrough, Sub-D 15 (m/m)

1 Vacuum side

2 Air side

C-815.VFU6 vacuum feedthrough for 10^{-9} hPa

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

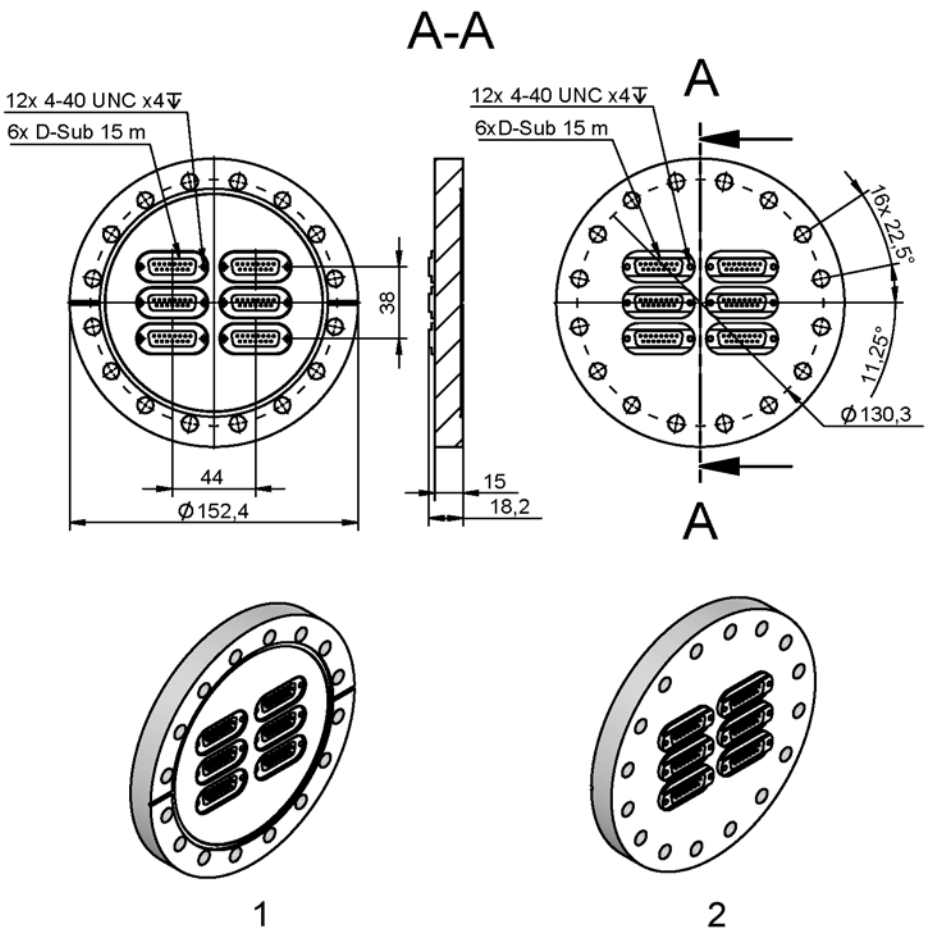


Figure 30: C-815.VFU6 vacuum feedthrough, Sub-D 15 (m/m)

1 Vacuum side

2 Air side

C-815.VFU15 vacuum feedthrough for 10^{-9} hPa

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

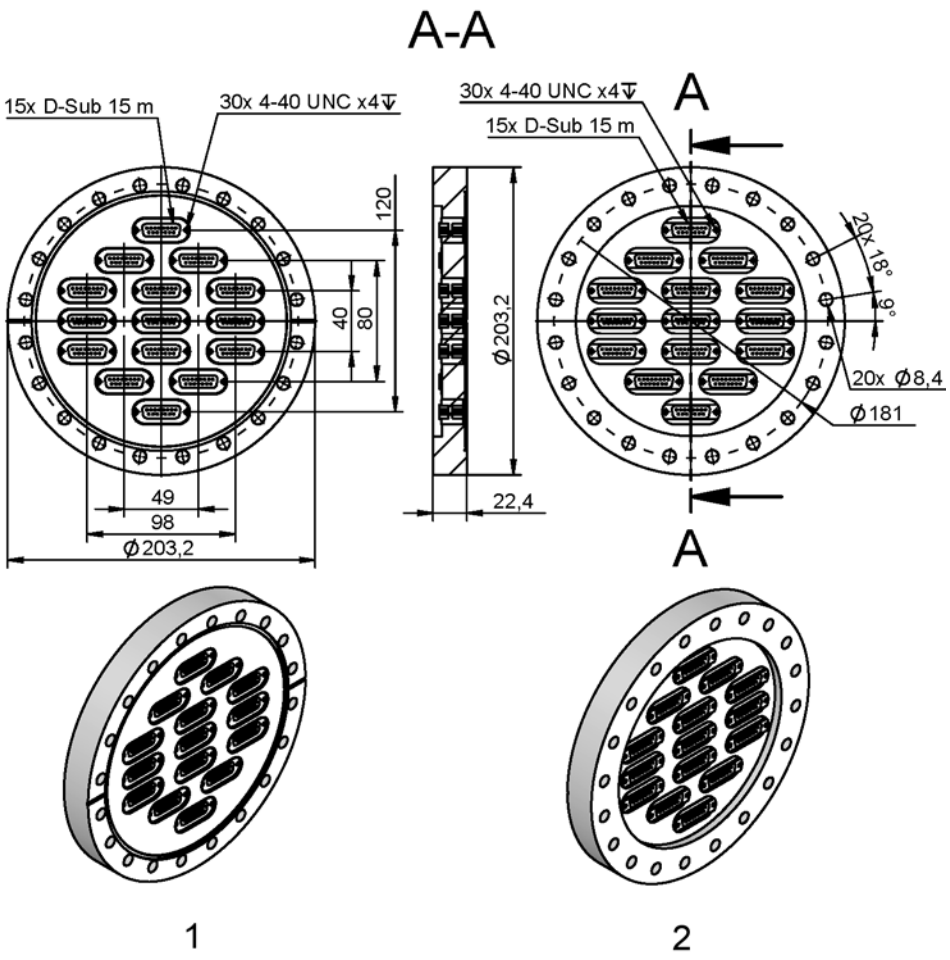


Figure 31: C-815.VFU15 vacuum feedthrough, Sub-D 15 (m/m)

1 Vacuum side

2 Air side

10.4 Pin Assignment

10.4.1 Q-545.xx0

Connector: Sub-D 15 (m)

The Sub-D 15 (m) connector transmits the signals of the drive and, for the models with sensor, in addition the signals of the sensor and of the ID chip.

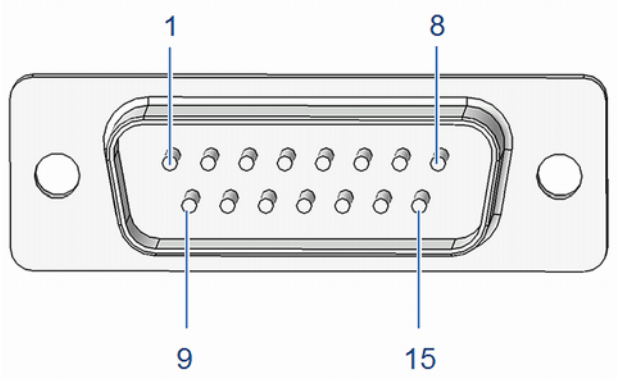


Figure 32: Sub-D 15 (m) connector

Pin	Signal[1]	Function	Direction
1	REF - [2]	Reference signal differential (-)	Output
2	Motor (-)	Motor signal differential (-)	Input
3	Motor (+)	Motor signal differential (+)	Input
4	V_{DD} [2]	Supply voltage (+5 V)	Input
5	-	-	-
6	ID chip data [2]	ID chip data	Output
7	SIN - [2]	Encoder A (-)	Output
8	COS - [2]	Encoder B (-)	Output
9	Motor (-)	Motor signal differential (-)	Input
10	GND	GND	GND
11	Motor (+)	Motor signal differential (+)	Input
12	-	-	-
13	REF + [2]	Reference signal differential (+)	Output
14	SIN + [2]	Encoder A (+)	Output
15	COS + [2]	Encoder B (+)	Output

[1] The "-" sign indicates that the corresponding pin has not been assigned.

[2] Only for models with sensor. Not assigned for models without sensor.

The cable shield is connected to the connector shell.

10.4.2 Q-545.xxU

Connector: Sub-D 15 (f)

The Sub-D 15 (f) connector transmits the signals of the drive and, for the models with sensor, in addition the signals of the sensor and of the ID chip.

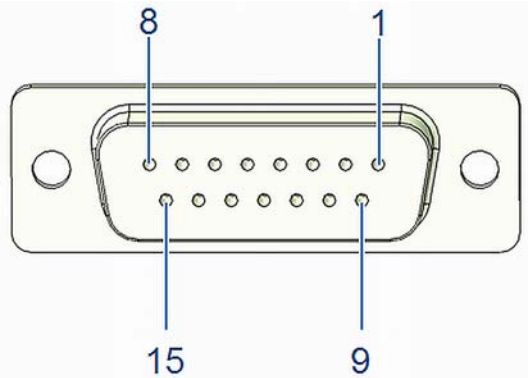


Figure 33: Sub-D 15 (f) connector

Pin	Signal[1]	Function	Direction
1	COS - [2]	Encoder B (-)	Output
2	SIN - [2]	Encoder A (-)	Output
3	ID chip data [2]	ID chip data [2]	Output
4	-	-	-
5	V_{DD} [2]	Supply voltage (+5 V)	Input
6	Motor (+)	Motor signal differential (+)	Input
7	Motor (-)	Motor signal differential (-)	Input
8	REF - [2]	Reference signal differential (-)	Output
9	COS + [2]	Encoder B (+)	Output
10	SIN + [2]	Encoder A (+)	Output
11	REF + [2]	Reference signal differential (+)	Output

Pin	Signal[1]	Function	Direction
12	-	-	-
13	Motor (+)	Motor signal differential (+)	Input
14	GND	GND	GND
15	Motor (-)	Motor signal differential (-)	Input

[1] The "-" sign indicates that the corresponding pin has not been assigned.

[2] Only for models with sensor. Not assigned for models without sensor.

The cable shield is connected to the connector shell.

10.4.3 C-815.VF Vacuum Feedthrough

Sub-D 15 (m/f)

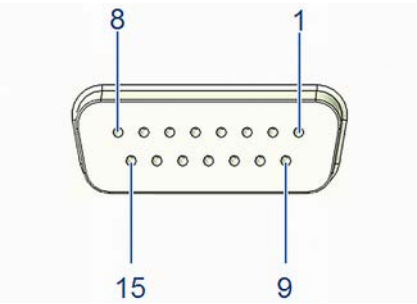


Figure 34: Vacuum side: Sub-D 15 (f) socket

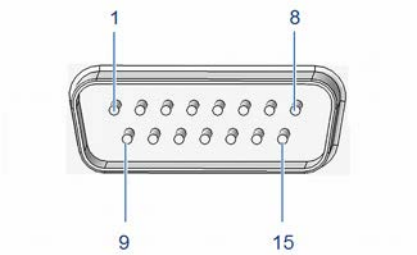


Figure 35: Air side: Sub-D 15 (m) panel plug

Vacuum side (f)			Air side (m)
Pin	**Signal**	**Function**	**Pin**
1	REF - [2]	Reference signal differential (-)	1
2	Motor (-)	Motor signal differential (-)	2
3	Motor (+)	Motor signal differential (+)	3
4	V_{DD} [2]	Supply voltage (+5 V)	4
5	-	-	5
6	ID chip data [2]	ID chip data	6
7	SIN - [2]	Encoder A (-)	7
8	COS - [2]	Encoder B (-)	8
9	Motor (-)	Motor signal differential (-)	9
10	GND	GND	10
11	Motor (+)	Motor signal differential (+)	11
12	-	-	12
13	REF + [2]	Reference signal differential (+)	13
14	SIN + [2]	Encoder A (+)	14
15	COS + [2]	Encoder B (+)	15

10.4.4 C-815.VFUx Vacuum Feedthrough

Sub-D 15 (m/m)

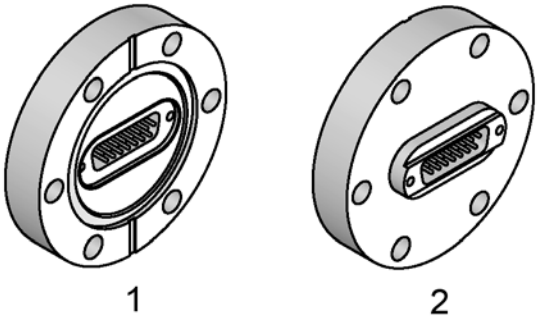


Figure 36: C-815.VFUx vacuum feedthrough

1 Vacuum side
2 Air side

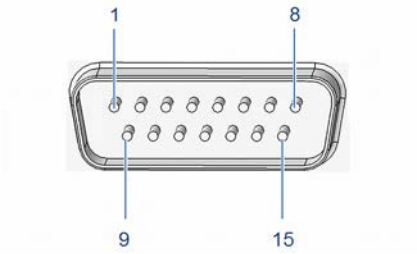


Figure 37: Sub-D 15 (m) panel plug

Vacuum side			Air side
Pin	**Signal**	**Function**	**Pin**
1	COS -	Encoder B (-)	8
2	SIN -	Encoder A (-)	7
3	ID chip data	ID chip data	6
4	-	-	5
5	V_{DD}	Supply voltage (+5 V)	4
6	Motor (+)	Motor signal differential (+)	3
7	Motor (-)	Motor signal differential (-)	2

Vacuum side			Air side
Pin	**Signal**	**Function**	**Pin**
8	REF -	Reference signal differential (-)	1
9	COS +	Encoder B (+)	15
10	SIN +	Encoder A (+)	14
11	REF +	Reference signal differential (+)	13
12	-	-	12
13	Motor (+)	Motor signal differential (+)	11
14	GND	GND	10
15	Motor (-)	Motor signal differential (-)	9

10.4.5 5604500041 Adapter

Sub-D 15 (m/m)

The adapter is only required if a Q-545.xxU model is to be operated at atmospheric pressure (i.e., without a vacuum feedthrough).

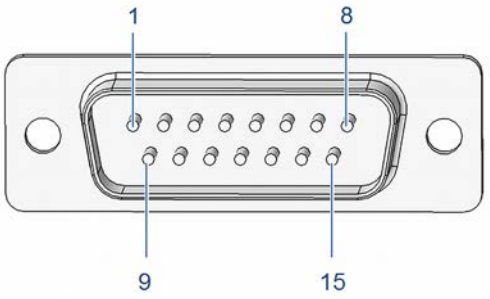


Figure 38: Sub-D 15 (m) connector

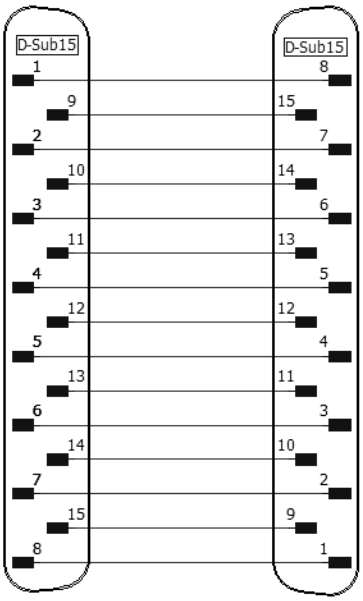


Figure 39: Pin assignment of the 5604500041 adapter

11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

In order to fulfil the responsibility as the product manufacturer, PI miCos GmbH undertakes environmentally correct disposal of all old PI miCos equipment made available on the market after 13 August 2005 without charge.

Any old PI miCos equipment can be sent free of charge to the following address:

PI miCos GmbH

Freiburger Strasse 30

79427 Eschbach, Germany

12 EC Declaration of Conformity

For the Q-545, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1:2010

EMC: EN 61326-1:2013

RoHS: EN 50581:2012